ANNUAL REPORT

OF

THE UNITED STATES

GEOLOGICAL AND GEOGRAPHICAL SURVEY

OF

THE TERRITORIES,

EMBRACING

COLORADO AND PARTS OF ADJACENT TERRITORIES;

BEING A

REPORT OF PROGRESS OF THE EXPLORATION FOR THE YEAR 1874.

BY

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CONDUCTED UNDER THE AUTHORITY OF THE SECRETARY
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OFFICE UNITED STATES GEOLOGICAL AND
GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, D. C., October 1, 1875.

SIR: I have the honor to present for publication the Annual Report of the United States Geological and Geographical Survey of the Territories, embracing a preliminary account of its operations in portions of Colorado during the season of 1874.

The headquarters of the survey in the field were made at Denver, as in the preceding year, as the most suitable point for procuring the outfit and making the necessary preparations for the various divisions which were to investigate the districts specially assigned to them by the geologist-in-charge. The entire survey was separated into seven divisions. Four were for regular topographical and geological duty, and were assigned to specific areas; one party for the primary triangulation; a photographic division, to which was attached a naturalist; a party for special topographical and geological study; and the quartermaster's division, that furnished all the parties above mentioned with supplies during their field-work.

The first division was composed as follows:—A. R. Marvine, assistant geologist, director; S. B. Ladd, topographer; Louis Chauvenet, assistant topographer; M. L. Ward and W. S. Holman, meteorological observers; E. A. Barber, botanist and collector; W. W. Williams, general assistant; together with two packers, cook, and hunter.

The party took the field on the 20th of July, crossing over Berthoud's Pass, and through the Middle Park into the North Park, by the Willow Creek Pass. The survey of the southern portion of this park employed the party for some time; and it was not until the middle of August that they crossed to the main field of their work west of the Park range.

This new area presented all the different forms surface-erosion peculiar to a granite, sedimentary, and lava country, making it an exceedingly interesting study both for its topography and geology. The great lava mesa situated at the head of the White River is cut by deep cañons that penetrate far into the plateau, dividing the mesa into what appear to be isolated masses, but which are all connected. One isthmus, from three to twelve feet in width and one hundred and twenty-five in length, connected a plateau, of several miles extent, with the main mesa. The highest portion of this mass is on the east side, and, from the base of the almost continuous cliffs which border it, the country descends in long, timbered slopes to the broad, open area of Egeria

Park, lying between them and the Park range. Portions of this park drain into the Grand, but the greater part into the Bear, the divide between the two being very low.

The old Salt Lake wagon-road enters here from Gore's Pass. The top of the plateau is a rolling country, with numerous isolated mountain-masses. It abounds with numerous small lakes, and is well timbered, chiefly with fine spruce. To the west, the plateau gradually falls, the lava top dies out, the sedimentary rocks appear on the surface, and the timber-growth changes to aspen and pine.

The valley of the Grand does not present the attractive agricultural features of the White and Bear Rivers. It has formed numerous cañons, which show in a very interesting manner the highly-colored rocks, bent and twisted by many folds. Dwarf cedars, juniper, and the finer pines cover the slopes for some distance up, and the ever occurring sage-brush the flat bottom-slopes. South of the Grand, and between that and the Eagle, the country rises in broken, irregular mountain-ridges to the rough snowy range, of which Mount Powell is the culminating point.

Going west of the plateau, the rain-fall becomes continually less until the party reached 108°, when it entered upon the dry, barren country of Western Colorado. Snow fell in considerable quantities early in October, and the clouds that hung around the topographical points caused a great deal of delay. The weather finally grew so bad that it was decided to work toward civilization. An attempt to reach the White River Indian agency by a trail across the mesa was frustrated by the snow. The party reached the top in a blinding snow-storm, with snow nearly two feet deep. One of the party, who had crossed with the mail two weeks before, reported the snow as belly-deep to a horse for fifteen miles, and in places for a considerable distance up to the top of the saddle. After one night's camp in the snow, and the storm still continuing, the party decided to turn back, and take the longer but easier route around the mesa. This route offered no difficulties, and they finally reached Rawlins Springs, the nearest point on the Union Pacific Railroad, November 27.

A barometric station was established at the agency, and one of the meteorological observers was there all the time. This station will serve as the base for all altitudes in the district. In October, this party divided, a portion remaining encamped at the mouth of the Eagle, where careful barometric readings were taken that will fix this important point.

Approximate determinations of the amount of water in the Eagle, Grand, and Bear Rivers were made, which will give an idea of the amount available for irrigation.

The amount surveyed is about forty-three hundred square miles, comprising a narrow strip of country, taking in the south side of North Park, stretching from Long's Peak to the Park range. The main portion is bordered by the Park range on the east, south by the Eagle and Grand

Rivers, and north by the Bear River. Westward the work extends nearly to longitude 108°.

The operations of this division during the field-season of 1874 were directed, first, to the survey of a narrow east and west strip along the southern edge of the North Park, thus extending the work of the previous season in the Middle Park northward to the parallel of 40° 30′ north latitude; and, secondly, the extension of the same work westward over the Park range and along the region of the Bear, White, and Grand Rivers, this being the principal field of work. Here, the northern boundary of the survey, 40° 30′, is practically the Bear River; while the southern boundary was formed by the Eagle River to its junction with the Grand, and below this point by the latter river itself; on the east the Park range, about in longitude 106° 30′, limited the area in question; while to the west the survey was carried to an irregular border, about touching, at its extreme point, the meridian of 108°. The narrow strip in the North Park probably covers over five hundred square miles, while the principal and more compact area at the west may be considered as averaging nearly seventy miles across east and west and nearly sixty miles north and south, or about four thousand square miles in area. Topographically, this area may be divided into three well-marked divisions: first, the region draining mostly northward into the Bear; secondly, that draining southward into the Grand and Eagle Rivers; and, thirdly, the basin of White River and its tributaries, which in itself forms a complete drainage-system, trending westward directly between the two preceding regions. At its source, the Bear, with tributaries of the Grand, quits the sources of the White, which rise in a great isolated mesa-mass of lava, between which and the Park range is the deposited basin of Egeria Park.

The whole region was examined in the usual manner of the survey: first, such observations were made as to enable a carefully-colored geological map to be constructed, showing the distribution and extent of the rocks, and formations of various ages or kinds, which compose the surface of the region; sections numerous enough to show how these various formations lie upon one another, or how they probably lie beneath the visible surface, or to show the various foldings or fractures to which they have been subjected and yielded; and as many detail-sections as possible, to determine the changes which take place in the character and thickness of these formations in their lateral extension, and to determine, as closely as possible, their relative ages and general paleontological relations. In this connection, the extent and mode of occurrence of all economical products, as minerals, building-stones, plasters, springs, etc., are noted as far as observed, while collections of specimens of the same, as well as of all rocks, fossils, etc., are made as far as possible. Second, and chiefly to enable some of this knowledge to be more accurately represented, such operations are carried on as to enable a map, or representation, of all the surface-features of the country to be prepared, its rivulets, streams, plains, hills, and mountains, its cañons

or valleys, its steeper or greater slopes, its peaks and passes, and this with all the accuracy that it is possible to give on a map printed on a scale of four miles to an inch, and in 200-foot contour-lines. These topographical observations are directly founded on a careful secondary triangulation, carried on simultaneously with them. At the principal stations of this triangulation, stone monuments from four to six or more feet in height were built, with a wooden stick, on which was deeply carved the number of the station and of the map (according to the scheme of maps of the survey), inserted in each, thus rendering them available in the future, when more accurately located by the primary triangulation, as data on which to base the usual United States land surveys when these may be needed in these distant regions, or for other purposes of references.

Further, the general quality and distribution of timber, bottom, agricultural, arid, or generally unavailable lands, were also made the subject of observation; while botanical, natural-history, and other specimens were collected as far as possible; and the amount of water flowing in the larger streams was made, in some cases, the subject of measurement. A permanent and quite complete meteorological station was established at the White River agency, the base of supplies of the party, while similar observations were at one time continuously taken for nearly three weeks at a point near the head of the White River, and again for nearly four weeks at the junction of the Eagle and Grand. In comparing with these bases the observations constantly made with the party, very complete and accurate hypsometric results will be obtained. In these observations, the usual mercurial mountain-barometer of James Green, with wet, dry, maxima, and minima thermometers, was employed.

As the general results, regarding the occurrence of economic products, it may be said that the series of older metamorphic rocks, such as the granites, schists, etc., of probable Archean age, in which alone the precious metals and minerals of Colorado have been found, and which, form the foundations on which all the bedded rocks, sandstones, limestones, etc., of the country rest, are brought to the surface and exposed only along the folded ridges of the Park range, and in the bottoms of a few cañons in some of the southern tributaries of White River, and of the neighboring tributaries of the Grand, and that it is only in these regions, therefore, that the precious minerals may be looked for. Along the northern portion of the district, north of the main valley of the White, and in the extreme west, the surface of the country is formed of rocks of Cretaceous age, which are, for the most part, horizontal beds, flexed here and there into quiet undulations. The coal of the region, which consists of a few seams of fair Lignitic coal, seems to be confined wholly to pretty definite horizons in the upper-middle and upper portions of this group; and as these particular horizons have been eroded away from the region in question, except at the north and west, it is here alone that it becomes worth while to search for coal. Farther west, it is

understood that both in quantity and quality, this coal improves. In the southeastern portion of the district, above the Grand and Eagle Rivers, the sedimentary rocks, from the extreme base of the Cretaceous down to the granite rocks of the Park range, occur, all thrown into a series of complicated and peculiar folds. Limestone occurs near the Grand in abundance, and on both the Grand and Eagle Rivers are great deposits of gypsum, though other economic products, except some salt and soda springs, will probably not be found here.

The imposing mesa about the head of White River and several larger areas near the Park range are composed of great floods of volcanic rock, which have poured over the country in comparatively recent times, but some of which are yet old enough to have experienced the vicissitudes of the Glacial period of the West, and to have received a profound impress from erosion, similar to that now going on over the whole country.

The topographical work of the party under my immediate direction was intrusted to Mr. G. B. Chittenden, and was divided into three parts: first, the mapping of the peculiar features of the morainal deposits in the Upper Arkansas Valley; secondly, the reworking of the topography of the Elk Mountains on a larger scale, and with more detail than was possible during the preceding season in the regular progress of the survey; and, finally, the laying down of the topography, and the line of junction of the metamorphic and sedimentary rocks, and also the coal-outcrops on the eastern base of the mountains, from Cañon City to the northern boundary of the Territory, making, in this latter division, small detailed maps where points of particular interest or peculiar complication made them seem desirable. In pursuance of this plan, the work began at Colorado Springs, in order to investigate that region in detail, before the main party would be ready to proceed across the South Park to the work in the west. Forty-five topographical stations were made on the sedimentary rocks, within ten miles of the springs, embracing the Garden of the Gods and Monument Park, so curious on account of their geological structure, and well worth mapping as typical geological features, which might be readily reached by the student traveling from the east. Joining the main party here, we crossed the South Park to the Arkansas Valley, carrying on a running survey of the road as we traveled. By short marches for five days up the valley, we were enabled to study out, with a good degree of care, the heavy masses of morainal deposits, which, for twenty miles or more, sweep out from the base of the high mountains which border the valley on the west to the present channel of the river. It will, of course, be impossible, in the time devoted to these moraines, to make a carefully-detailed map of them, but enough notes were taken to give quite accurately their relations to each other, their general forms and magnitudes, and their particular trends, together with their relations to the surrounding mountains.

Leaving this region about the middle of August, we crossed the main divide by way of the Lake Creek Pass and entered the Elk Mountains.

This range reaches out from near the headwaters of the Gunnison River, forty miles to the northwest, and, though not generally as high as the other ranges of Northern Colorado, is by far the most rugged of them all. The reasons for re-examining this range, when it had been surveyed in the regular progress of the work, were two: first, their ruggedness and inaccessibility had made the difficulty of working them last year so great, that they were not surveyed in a style quite up to the standard of the remainder of the work; and, secondly, that their geological importance made it a matter of particular scientific interest that they should be carefully studied and mapped.

The geologist and topographer worked side by side through them, making forty-two high mountain-stations; Mr. Holmes sketching the different portions of the whole mass from as many points as possible. They contain about eight hundred square miles, and will be mapped on a scale of one mile to the inch.

Marching from here by way of the Twin Lakes and South Park to Cañon City, we carried on a running survey along our route, and from the latter place commenced work, on the last part of the summer's plan, the mapping of the sedimentary border-line and that of the coal from here to the Wyoming line. This work, carried on without interruption, was finished by Mr. Chittenden, Mr. Holmes, and myself on the 20th of October; it having required seventy-four topographical stations. This survey was of a great deal of practical as well as scientific importance, and of immediate need, since, in the coal-series, we were enabled to lay down pretty closely that broken winding line more than two hundred miles in length inside of which no coal might be found. The labor involved in carefully laying down this line cannot be realized until one notices the almost numberless prospect-holes that have been sunk into the worthless black shales which, all along the base of the mountains, lie inside the coal-series and tempt the settlers into profitless investments and unrequited diggings after coal.

In carrying on this last survey, the Land-Office work has been of great assistance, and also the careful studies of Captain Berthoud of the coal lying to the west and north of Denver.

The maps produced from this special survey and included in this report are as follows:—

1. *A map of the eastern base of the mountains* from below the Arkansas River to the northern line of the Territory, on a scale of two miles to one inch. On this map are plotted the line of coal-outcrop, the junction of the sedimentary and metamorphic rocks, and the inner limits of the Cretaceous.

2. *A map of the Elk Mountains* on a scale of one mile to an inch, plotted with 200-foot contours.*

3. *A map of the Upper Arkansas Valley*, showing the heavy morainal deposits in the vicinity of the Twin Lakes, on a scale of one mile to an inch.

*These maps are all reduced one-half for publication.

4. *A map in the vicinity of Colorado Springs*, on a scale of one-half a mile to an inch, made principally for geological purposes.

The meanders of traveled roads will be plotted on the final maps of Colorado.

While all this work was looked upon as *special work*, and done with more detail than the regular work of the survey, the results will, of course, be incorporated in the final maps of the Territory, and form a part of them.

During the season, Mr. Chittenden made 156 topographical stations, and the total area surveyed was over four thousand square miles. Mr. W. H. Holmes labored with his usual zéal and skill during the entire season, and much of the accuracy and value of the work is due to him.

During the sickness of a member of the party at the base of Sopris Peak, I was detained about twenty days. In the mean time, Messrs. Holmes and Chittenden made a careful geological and topographical study of the northwestern portion of the Elk Mountains, the results of which will be found embodied in Mr. Holmes's report. Great numbers of topographical and geological sketches were made by Mr. Holmes, which will serve in a remarkably clear manner to illustrate the structure of the interesting regions surveyed.

The district assigned to the second division is limited on the north by the Eagle and Grand Rivers, west by the west line of Colorado, south by the parallel of latitude 38° 20′, and east by the 107th meridian. The area of this district is about seven thousand square miles, of which the party completed 5,300 square miles.

The plan of the geodetic and topographical work is as follows:

1st. The latitude and longitude of certain points are determined by astronomical observations as accurately as the present state of astronomical science will allow. This work has been done for us, thus far, by the United States Coast Survey. For the prosecution of the survey of Colorado, the latitude and longitude of Sherman and Cheyenne, Wyoming Territory, and Denver, Colorado Springs, and Trinidad, Colorado Territory, have been determined by them.

2d. From a base-line measured as accurately as possible, a system of primary triangulation is expanded and extended to cover the area to be surveyed with a net-work of triangles. By this operation, the positions of a limited number of points are established with accuracy. Connecting this system of triangulation with the points whose positions have been established by astronomical observation, the latitudes and longitudes of the primary points are established. The first base-line for the primary triangulation of Colorado was measured principally on the track of the Kansas Pacific Railroad near Denver. Its length is between six and seven miles. Check-bases at Colorado Springs and in San Luis Valley have also been measured and connected with the triangulation. The angles are measured by a 15-inch theodolite, reading to ten seconds, using artificial signals. The primary triangulation is carried

on by a special party. Using the lines of the primary system as bases, the topographers of the division carry on the secondary triangulation, locating points within the triangles of the primary system. In the secondary system, as in the primary, all three angles of the triangles are measured, and, in most cases, artificial signals are used on the stations. The instrument used for this work is a sort of theodolite, reading minutes. The stations for triangulation and topography are, in most cases, the highest and most commanding points, and are so selected that the limits of work from one will reach the limits from those around it. From a station, a sketch-map of all the country within the range of vision is made, as also a prospective sketch. Angles taken on prominent points and recorded on these sketches serve to locate them, and thus to correct the sketch-map. The distance between stations must depend on the character of the country, but the average distance apart is seven to ten miles. For the prosecution of its work during the past season, this division made eighty-six stations, or one station to every eight miles of area.

The most prominent geographical features occupied by this division are in brief as follows: On the north, the Eagle or Piney River flows, through most of its course, in a broad fine valley, having a course nearly west, interrupted here and there by short cañons. At its mouth, it is a large stream, barely fordable at the lowest stage of water. The Grand River, sometimes called the Blue or Bunkara, below the mouth of the Eagle, is in a close cañon about thirty miles, interrupted by a short meadow at the mouth of Roaring Fork. Below this cañon, the river flows sluggishly through a broad meadow, which extends for fully fifty miles, but is narrowed in the middle of its length, where the river cuts through a plateau. Below this meadow, the river enters another cañon about eighteen miles in length, and of no great height, from which it flows into the broad valley in which it meets the Gunnison. The course of the Grand, at the mouth of the Eagle, is about west, which direction gradually changes to southwest, and then near the mouth of the Gunnison again to the west.

The drainage of the southern part of the district is by the Gunnison River. This stream takes all the water from the southern slopes of the Elk Mountains, the western slopes of the Saguache range, and the northern slopes of the Uncompahgre Mountains. For twenty-five miles below the mouth of Cochetopa Creek, this river is in a narrow valley, which is diversified by long tongues of mesa, which separate the numerous streams entering the river on either side. Below this valley is a very heavy cañon cut in a high plateau for fifteen miles. The plateau is horizontal, 10,000 feet high, and the course of the river is nearly west across it, the depth of the cañon increasing with the fall of the river from 3,000 to 4,000 feet. At this point, the plateau breaks off abruptly on the north side, and, while preserving nearly the same height at the edge of the cañon, slopes off gradually toward the north, having

the appearance of long hog-backs. On the south side, the plateau preserves its horizontality for a few miles, then breaks off, leaving a ridge of upturned beds only to separate the river from the valley of the Uncompahgre. At a point about thirty miles below the head of the cañon, the river changes its course abruptly from west to north, and flows parallel to the slope of long hog-backs. It holds this course for about eighteen miles, then, at the mouth of the North Fork, a large affluent from the north, it turns again abruptly to the west, and a few miles farther suddenly emerges from the cañon into the broad valley of the Uncompahgre. The character of this cañon in its upper part is extremely rugged; its walls are precipitous, and there is hardly a place where a man could clamber down to the bottom. The river fills the bottom of the cañon, leaving no beach anywhere. The material of the cañon-walls in the upper two-thirds is gneiss and in the lower third stratified rock. The valley of the Uncompahgre River is very broad, extending forty miles up the Uncompahgre River and twenty miles down the Gunnison. Below this, the river falls through a cañon, which, with slight interruptions, extends to the mouth of the river, while the country back from the river is a flat open valley.

The Elk Mountains extend into this district, occupying an area of about one thousand five hundred square miles in the southwestern part. Their character is not that of a continuous range, but of groups of mountains and isolated peaks. The elevation of the highest does not exceed 13,500 feet, and the average of the peaks is scarcely 13,000 feet. These mountains are drained entirely by the Gunnison; the northern slopes by its North Fork. Besides these mountains, the country is entirely plateau and broad valleys. The plateau has an elevation of 8,500 to 10,000 feet, sloping gradually toward the west. The elevation of the mouth of the Gunnison River is about 4,200 feet; at the mouth of the Uncompahgre, 4,500; and the general elevation of the Uncompahgre Valley, 4,500 to 5,000 feet; that of the mouth of Cochetopa Creek, 7,400 feet; and of the Grand River, at the mouth of the Eagle, about 7,000 feet.

The division was constituted as follows, viz: Henry Gannett, topographer, in charge of party; Dr. A. C. Peale, geologist; Fred. Owens, assistant topographer; Frank Kellogg, assistant; Arch. R. Balloch, general assistant; with two packers and a cook.

The party left Denver on July 21, traveled one hundred and fifty miles to their field of work, commenced work August 3, ended work October 29, and reached Denver about the middle of November.

On July 14, 1874, the San Juan or third division of the United States Geological and Geographical Survey left Denver for the field. It consisted of A. D. Wilson, topographer, directing; F. Rhoda, his assistant; F. M. Endlich, geologist; and Mr. Gallup, who was for a short time attached as barometric observer. The region assigned to this division was the one generally known as the "San Juan country". In 1860 and 1861, a

party of prospectors, the "Baker's party", had reached a section of country that was said to abound in silver and gold. After enduring many hardships, a portion of the men succeeded in again reaching settlements, while others were killed by the Indians. Ten years later, the mining-region was brought into public notice a second time, more particularly by the discovery and working of the "Little Giant" mine. Since then, many prospectors and capitalists have examined the indications of ore, and active mining has taken the place of mere preliminary examination. In 1873, the tract of land supposed to contain all or nearly all of the metalliferous lodes was purchased from the Ute Indians by the United States Government. It was therefore one of the main objects of the San Juan division to inquire into the geological and mineralogical characteristics of these lodes, with a view to obtain some idea regarding their relations and value. A report thereon will be found in the fourth chapter of the geological report of F. M. Endlich.

In every respect, the country surveyed was found to be of such extraordinary interest, and the demand for information with regard thereto was so apparent, that it was deemed advisable to publish at once a portion of the results obtained. Bulletin No. 3, of the second series, 1875, contains a drainage-map of the country; a report by A. D. Wilson, referring to routes, roads, grades, etc.; one by F. M. Endlich on the mines; and an itinerary, together with hypsometric data, by F. Rhoda. All will be incorporated in the subjoined report in their respective places.

While Colorado has furnished so many districts of rugged mountain country, the one surveyed by this party during 1874 surpassed all. In consequence of this character, it was not possible to complete so large an area as was first intended, and about five thousand two hundred square miles were surveyed. Of these, three thousand two hundred were plotted during the winter following, and the geological report confines itself to them. The remainder will be attached to the work of 1875, thus obviating the necessity of mapping an isolated area.

From the report and sketches accompanying, it will be seen that the district was one of unusual character, containing phenomena of great geological importance. Enormous quantities of volcanic rocks were found to form the highest peaks, reaching an altitude of 14,280 feet above sea-level, while many unique features of detail were noted in the same formation. Metamorphics and sedimentaries were also observed, the former rising to very considerable altitudes. As might be expected in a country so favorable to the formation of water-courses, the head-waters of several large streams were discovered and mapped. Among the most prominent are those of the Rio Grande, Rio Animas, Rio Dolores, Rio San Miguel, Rio Piedra, and the Uncompahgre. Ethnologically, the southern section was found to present interesting data.

Through co-operation of the geological work with that of Mr. Wilson, the topographer, it became possible to render a geological map that represents the horizontal distribution of the various formations and their members, while sections display the vertical arrangement.

On October 19, 1874, the party again reached Denver, after having completed the work above specified. During the season, sixty-five topographical stations were made and seventy-four camps. Of these stations, eighteen were over 13,000 feet above sea-level.

The photographic and naturalist's division was again under the supervision of Mr. W. H. Jackson, the photographer, who has been connected with the survey for the past five years in the same capacity. The party organized in Denver, and took the field July 21. It comprised the photographer; Mr. Anthony, his assistant; Mr. E. Ingersoll, naturalist; and Mr. Frank Smart, assistant, with two packers and a cook.

Middle Park was first visited, as it had not been worked up the previous season. A series of beautiful and very characteristic views of the peculiar features of the park were secured, including views about Grand Lake, the Hot Springs, the Great Cañon of the Grand, and the magnificent mountain-forms and the charming vista as seen along the Blue River. From the head of the Blue, the party progressed southward, via the Arkansas, Poncha, and Cochetopa Passes, to the Los Pinos agency for the Ute Indians, where a series of views were secured illustrating their life and peculiarities. The San Juan Mountains was the next objective point. A camp was established in the upper end of Baker's Park, in which was left all extra material in charge of two or three of the men, and then, traveling with but few animals and very light packs, rapid side-trips were made into all the strongholds and fastnesses of the grandest mountains in all Colorado. Panoramic views from the tops of the highest peaks were secured, illustrating, by bird's-eye views, the geology and topography of the whole mountain-system. Especial attention has been paid, all the time, to make these views instructive as well as pleasing to the eye, and the system of panoramic views which has been carried out has been of very great assistance to the topographers in working up their notes and expressing the peculiarities of mountain-forms. To the geologist, also, they prove of great value in recalling to the mind the surface-features, inclination of strata, proportion of valley to mountain land and of timber to the rocky summits lying above it.

From the permanent camp in Baker's Park, a side-trip was made into the southwestern corner of the Territory, in search of the picturesque and interesting ruins of the habitations of a long-forgotten race. No search was made until the Rio Mancos was reached; but, from this point, ruins without number covered the plateau and filled the valleys and cañons. Through the cañons of the Rio Mancos, were found houses of two stories in height, in the escarpment of the mesa, 800 to 1,000 feet perpendicularly above the valley, of well-dressed sandstone, true in all their angles, laid in a firm and tenacious mortar, and the inside plastered and paneled in two colors. The greater majority of these houses were smaller, but as perfectly built as the larger ones, and all

were very difficult of access, and resembled swallows' nests more than anything else. To reach these with the photographic apparatus, it had to be hauled up with long ropes taken from the pack-animals. From near the mouth of the Rio Mancos, the party proceeded northwesterly into Utah, finding group after group of towns and isolated watch-towers perched upon great bowlders and upon the promontories of the mesas. In one place was found a wall, evidently surrounding a town of a very considerable population, which was fully twenty feet in thickness, the outer surface of dressed stone, laid perfectly true, the space between filled with large undressed blocks in adobe mortar.

The entire trip to these ruins, from and back to Baker's Park, comprised about three hundred and fifty miles of traveling. Only two weeks could be devoted to it, which necessitated a somewhat superficial examination. Two series of views were made, the stereoscopic and five-by-eight plate. About forty negatives were made altogether, illustrating perfectly all the leading features in a very unique series of views.

From Baker's Park, the party returned by rapid marches, via the Rio Grande, San Luis Valley, and Mosca Pass, to Colorado Springs, where they met with the special party under my charge. Mr. Jackson joined him with his apparatus for a few days, while his party proceeded to Denver and disbanded. The four or five days he was with the special party, about one hundred additional negatives were made, mostly of camp-life and the manner of conducting the various operations of the survey while in the field. The result of the trip sums up as follows: 350 negatives, stereoscopic and five-by-eight, and the most extensive and interesting conchological collection ever made in the Territories. The party was out eighty-four days, making sixty camps, and traveling one thousand two hundred and forty miles.

Not a negative was broken or lost on the trip, and the naturalist's and different zoological and entomological collections came in safe.

The work of the survey during the season of 1875 will be extended westward in Colorado to the meridian of longitude 109° 30′. The area now remaining to be explored lies west of 108° on the western slope of the main range of the Rocky Mountains and comprising the eastern portion of the drainage of the great Colorado River. Hundreds of streams of greater or less size cut deep gorges through this country in their westward course to the Colorado River. There are some groups of mountains yet to be surveyed, but the highest peaks have already been located.

According to the instructions given by the Department:

First. There shall be two classes of maps: one known as "general", the other as "special" maps; and the "general" maps shall be subdivided into two classes, viz, "topographical" and "geological".

Second. The "general" maps shall be on a scale of four miles to an inch, or $\frac{1}{253440}$. The sheets thereof shall be twenty-six (26) inches long by thirty-seven (37) inches wide, including the border, and be folded once. The area to be represented on each

sheet shall be two and one-half degrees in longitude and one and one-fourth degrees in latitude. The 112th meridian shall be taken as the standard from which the maps are to be projected in an easterly and westerly direction, and the 38th parallel as the standard from which they shall be projected in a northerly and southerly direction; these lines forming the division-lines between the atlas-sheets adjacent thereunto.

Third. Maps or charts of the second or "special" class may be constructed on other scales and embracing other areas, whenever it shall be found necessary for the purpose of properly representing mining-districts, mineral, agricultural, pasture, or timber lands, or for other special purposes.

At the end of the next season, if suitable appropriations are made by Congress for the purpose, the survey will have completed the most rugged and mountainous portion of our continent, lying between meridians 104° 30′ and 109° 30′ and parallels 40° 45′ and 40° 30′. This will form an atlas of six sheets, each comprising about 11,500 square miles, or a total of about 69,000 square miles. These maps are intended to express not only the topographical features, but the geological also; and, in accordance with the directions of the Secretary of the Interior, these charts will indicate the areas of grass, timber, and mineral lands, and such other country as may be found to be susceptible of cultivation by irrigation.

Numerous special maps of the mining-regions, isolated mountain-ranges, and other localities remarkable for their complicated geological structure, have been prepared on different scales. Much more of this detailed study of interesting localities will be made when the final maps are completed. Collections of great value were made in geology and mineralogy, all of which will be reported on in due time.

Since the publication of the annual report for 1873, several volumes have appeared in connection with the survey, which must be regarded as of great value. Volume II of the quarto series, by Professor Cope, on the "Cretaceous Vertebrata of the Western Territories", contains 304 pages text, with 57 plates. Volume VI of the quarto series, on the "Cretaceous Flora of the Dakota Group", by Leo Lesquereux, constitutes an original contribution to the vegetable paleontology of America, and will prove very useful in fixing a most important geological horizon. It contains 136 pages, with 30 plates. Much new material has come to hand since the publication of that memoir, a portion of which will be found in this report. A third edition of the "List of Elevations" and a second edition of the "Catalogue of Photographs" have been printed to supply the demand for the miscellaneous publications. The most important volume of the miscellaneous series, however, is the "Birds of the Northwest", by Dr. Elliott Coues, which comprises over eight hundred closely-printed octavo pages. Much of the text is written in popular style, treating of the habits, or, as it were, the domestic life, of the birds; and on this account the demand for it among our people has been unusually great. Although it does not pretend to be a general work on the ornithology of the Western Territories, it contains a more or less complete descriptive list of four-fifths of the birds of the United States.

The memoirs that are either now in press or in an advanced state of preparation are numerous and important.

Volume IX, "The Fossil Invertebrata of the Western Territories," by F. B. Meek, is nearly through the press. It will contain 45 plates, with a great number of wood-cuts scattered through the text. Mr. Meek has most thoroughly elaborated every genus, and given the synonymy of all the species with unusual care. He regards this memoir as his great life-work, and it will add greatly to his fame as a paleontologist.

Volume X will be a "Monograph of the Geomitrid Moths", by Dr. A. S. Packard. It will form a memoir of 450 pages quarto, with 13 plates, on some of which are engraved one hundred figures. This work is now rapidly passing through the press.

Volume VII, "The Fossil Flora of the Lignitic Tertiary Formation of the Western Territories", by Leo Lesquereux, is intended to be a monograph of that subject. It will contain sixty-five quarto plates, all of which have been engraved by Messrs. Sinclair and Son, Philadelphia. Mr. Lesquereux is now at work on the text, and it is expected to be much superior to the Cretaceous Flora, which was received with such marked favor throughout the scientific world.

Volume VIII was originally designed to form an extended memoir on the Fossil Flora of the Cretaceous and Tertiary formations of the West, by Dr. J. S. Newberry. Twenty-six plates have been engraved, and an edition of 2,500 copies printed for over four years. It is to be hoped that some portion of this volume will be issued the present season.

A very interesting memoir, in octavo form, entitled "The Ethnography and Philology of the Hidatsa Indians (Minnetarees of the Upper Missouri) is now in the press. It was prepared at my request by Dr. Washington Mathews, U. S. A. Dr. Mathews spent some years at Fort Berthold, on the Upper Missouri, as surgeon of the military post, and his leisure time was devoted to the study of the language and history of this interesting tribe. An edition of 100 copies was printed by Mr. Shea, of New York; but since that time Dr. Mathews has very much enlarged and improved the memoir, and many portions of it he has entirely rewritten. I had originally intended that it should be substituted for a chapter I had written on this, many years ago, in a volume on the Indian tribes of the Northwest, which is intended to form one of the quarto series of the Survey; but when I found the manuscript to be so elaborate and complete, I preferred to issue it as a separate volume or monograph. I am confident that this memoir will be received with great favor, and that scholars in this country and in Europe will be profoundly grateful for this his labor of love.

The Bulletin of the Survey was originally started to embrace such articles as demanded immediate publication on account of their peculiar value or character. Many new species of animals and plants have been collected from time to time, which needed to be published promptly to

secure for the Survey that priority of discovery which is its right. The first two numbers, issued during the year 1874, are not paged consecutively; but those of the second series, which have been issued during the year 1875, will be paged consecutively, and the illustrations numbered, so that at the close of the year all the numbers may be gathered together and bound in one volume. A title-page, table of contents, and a complete index will be printed in the final number of each year. The numbers for the year 1874 and 1875 may be bound together as volume I. The irregularities in some of the publications are due to the unexpected progress of the Survey and the acquisition of an unusual amount of material.

The history of the Survey, from the small appropriation of $5,000 in 1867, was briefly told in the Annual Report of last year. It has continued from year to year with a constant growth, though dependent upon the annual appropriation, which will cease or be renewed each year at the option of Congress.

During the years 1867 and 1868, the Survey was under the Commissioner of the General Land-Office, and the two small annual reports were incorporated in the annual volume of that Bureau.

In 1869, the Survey was placed under the Secretary of the Interior, and the first independent annual report was made. When the demand was so great that a reprint of the report of 1869 was ordered, I united the two small reports of 1867 and 1868 with the report of 1869, as First, Second, and Third Annual Reports of the Survey.

The original plan of the quarto series only extended to five volumes. Volume V was to include all the natural history, and on the title-page of volumes I and V it is stated that the entire series will be in five volumes, of which the Acrididæ was to be the first part; but the materials in all branches accumulated so rapidly that the number of volumes was increased, and at the present time it will be limited only by the duration of the Survey.

The annual reports will be continued from year to year. Circumstances beyond the control of the geologist-in-charge may delay them, as in the case of the present one, but they will appear as soon as they can be prepared.

Besides the regular members of the Survey, there are several collaborators, whose time is more or less occupied in the preparation of special reports. Prof. Leo Lesquereux has been continuously connected with the Survey for several years, with a regular salary, devoted to the elaboration of reports on vegetable paleontology. Mr. F. B. Meek has also been a member of the Survey most of the time since 1867, with a fixed salary, as paleontologist. Professor Cope has prepared the reports on Vertebrata, and will continue to devote his time at intervals to that special department. Dr. A. S. Packard spent several months during the past summer in Colorado, Wyoming, and Utah under the auspices of the Survey, making large collections in his favorite branches, entomology

and invertebrate natural history generally. The results of his labors will appear in the annual reports, and in the beautiful quarto volume on the Geometrid Moths. Mr. P. R. Uhler visited Colorado during the summer. His collection of insects amounted to about 1,000 species. In the Annual Report for 1875, he will present an elaborate essay on the geographical distribution of insects. A very valuable paper on the Hemiptera of our Western Territories appeared in No. 5 of the Bulletins for the year 1875, illustrated with wood-cuts.

Two volumes, quarto, by Professor Cope, are in course of preparation, and will be published within a year if the Government provides the money for completing the engraving:—

Volume III, "Vertebrate Paleontology of the Eocene Formations of the West."

Part I. Distribution and Relations of the Tertiary Basins of the West.

Part II. The Vertebrata of the Eocene.

Part III. The Relations of the Fauna of the Eocene.

Volume IV, "Vertebrate Paleontology of the Miocene Formations of the West."

Part I. The Fauna of the White River Epoch.

Part II. The Fauna of the Loup Fork Epoch.

Part III. The Relations of the Fauna of the White River and Loup Fork Epochs.

The Survey is under great obligations to Dr. Elliott Coues, U. S. A., Mr. Robert Ridgway, and Mr. Samuel H. Scudder, for very valuable contributions to its publications.

The obligations of the Survey for favors of various kinds have been numerous as usual, but few of them can be mentioned in this connection.

From D. Appleton & Co., of New York, very great assistance has been received by permitting the use of the illustrations of Colorado scenery, taken from their magnificent publication "Picturesque America." The publishers of that work were permitted by the Interior Department to use the photographs of the Survey on condition that the Survey should have the electrotypes of the illustrations for use in the reports, and some of the beautiful cuts in this report are the result of their generosity.

The illustrations for this report have been prepared in part, while the text was passing through the press. This fact will account for irregularities in the numbering of them. The pen-sketches and sections were made by Mr. W. H. Holmes, a member of the Survey. For beauty and accuracy they cannot be surpassed, and they add greatly to the value of the report.

To the Union Pacific, Denver Pacific, Kansas Pacific, and Denver and Rio Grande Railroads, the Survey is under obligations for half-fare tickets for its members.

The various changes which have occurred in the *personnel* of the

party during the past year has thrown an immense amount of executive labor on me, which has exhausted my strength, and consumed my time to such an extent that I have not been able to give the necessary attention and study to my portion of the report. The editing of so many publications is sufficient labor for one person, and yet this is the smallest duty that has devolved on the geologist-in-charge. The various executive duties, as correspondence, foreign exchange, settlement of accounts, and the supervision of the parties in the field and office, seem to increase from year to year, so that only mere fragments of my time can be devoted to scientific study.

The present annual report is submitted with the belief that it contains much that is new and interesting to geologists and the intelligent world generally.

Very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

Hon. Z. CHANDLER,
Secretary of the Interior.

CHAPTER I.

BRIEF HISTORY OF THE LIGNITIC GROUP; FIRST STUDIED ON THE UPPER MISSOURI—EARLY VIEWS ENTERTAINED BY MEEK, NEWBERRY, AND OTHER PALEONTOLOGISTS ON THE AGE OF THIS GROUP—THE LIGNITIC GROUP OF THE NORTHWEST BELIEVED TO BE CONTINUOUS SOUTHWARD WITH THE COLORADO AND LARAMI BEDS.

In this chapter, I desire to note, as briefly as possible, the progress of the development of the Lignitic group of the Western Territories; and in doing so I need not go back farther in the past than the commencement of my own explorations on the Upper Missouri in 1854. Prior to that time, the observations that had been made by various travelers in regard to the existence of coal-beds in different parts of the West were of so indefinite a character that they cannot be used as evidence, though they may form a part of the early history of discovery.

I have frequently stated in my former reports that I regarded this group as, in many respects, the most important one in the West; that, in its relations to the well-defined Cretaceous group below it, it had a more important bearing on the physical history of the growth of the western portion of our continent than any other in the geological scale. Although this formation has been studied with great zeal by several parties within a few years, and most important additions to geology have resulted therefrom, there is evidently much more work to be done before all the problems will be solved with sufficient clearness for our entire satisfaction. That the evidence is very conflicting is shown by the wide differences of opinion that are entertained in regard to its age by geologists and paleontologists whose views have great weight in the scientific world.

The assistant geologists connected with the survey under my charge have been continually instructed to gather all the materials possible bearing on the age of this group, while Messrs. Meek, Lesquereux, and Cope have been urged to study the subject from their own peculiar standpoints, regardless of unity of results. Many extremely valuable and instructive memoirs have already appeared in the reports of the Survey touching upon this group, and several more are in process of preparation or publication.

One fruitful source of difference of opinion has been in the misunderstanding in regard to the different horizons of the coal-strata of the West. That there are important coal-beds in rocks of well-defined Cretaceous age cannot be disputed, and I have long since yielded that point. What we wish to show more clearly is that there exists in the West a distinct series of strata which we have called the Lignitic group, and that it is entirely separate, paleontologically and geologically, from a great group of strata in the Lower Cretaceous, and perhaps extending down into the Jurassic, which contains a great number of thick and valuable beds of coal. It is not necessary to discuss the question whether the term Lignitic shall be applied to the coal of either or both groups. I have used the term Lignitic for the upper group without reference to the

quality of its fuel, simply to distinguish it from the other great group of older date, the age of which is not questioned.

The time has now come, as it seems to me, when the materials are so abundant that the subject can be reviewed with some care. It is well known that I have held with some tenacity the opinion that the coal-formations of the West are of Tertiary age; and I still regard the Lignitic group proper as transitional or Lower Eocene, and shall so regard its age until the evidence to the contrary is much stronger than any which has been presented up to the present time. When, however, the proof is sufficient to decide the Cretaceous age of the group, I shall accept the verdict without hesitation. It is somewhat doubtful whether the age will ever be decided positively to the satisfaction of all parties; still we shall see in the course of this report that the character of the paleontological as well as the strictly geological evidence is such that it is not a matter of importance whether the entire group be placed in the Lower Tertiary or Upper Cretaceous, and it is most probable that the testimony of the different paleontologists will always be as conflicting as it is at present.

In order that the reasons for my belief in the Tertiary age of the Lignitic group may be more clearly understood and harmonized with the present state of our knowledge of the subject, I will give a brief history of the commencement and progress of its examination.

My first knowledge of this group was obtained in the summer of 1854, when I made a somewhat careful examination of the beds from their first appearance on the Missouri River near Fort Clarke to the mouth of the Yellowstone, and thence up that river to a point near the mouth of the Big Horn. In all this distance, about six hundred miles, following the windings of the river, the Cretaceous beds appear but once, and then only along the bed of the river for a few miles, while the entire country, with this exception, is occupied with the Lignitic group. The area of this formation on the Upper Missouri cannot be less than one hundred thousand square miles, and extends far north across the northern boundary of the United States into the British possessions. This group everywhere rests upon well-defined Cretaceous beds, which we have all along regarded as the highest known in the West, and have received the name of the Fox Hills group, from a locality on the Missouri River called the Fox Hills, or Fox Ridge, where this formation was first studied, and was very full of molluscan life. There is a gradual passage upward from the black plastic, shaly clays of No. 4, or the Fort Pierre group, to the yellow calcareous clays of the Fox Hills group, and at the upper portion, the sediments are arranged in thin layers, very arenaceous, and indicative of their deposition in turbulent as well as shallow waters. In these arenaceous sediments, the well-marked marine life ceases to exist, and soon after appear the brackish-water species. Between the Big Cheyenne and the Moreau Rivers, branches of the Missouri that come in from the west side, the Lignitic strata overlap those of Cretaceous age, and in the lower beds occurs a species of *Ostrea* associated with some other brackish-water forms. I am not positive as to the exact position of these fossils, but I am confident that a bed of gray sandstone, with a layer of impure coal or Lignite lie, below any of the brackish-water forms found in the Northwest. Scattered over the weathered surface of these Lower Lignitic beds, and believed, without doubt, to have been originally imbedded in them, were found several specimens of Vertebrata which have been regarded by Professor Cope as characteristic of the Cretaceous era. So far as the Northwest is concerned, the brackish-water beds are not more than 200 feet in thickness, while those that are

purely fresh-water must reach an aggregate thickness of 3,000 to 5,000 feet. During the years 1854 and 1855, I studied this group on the Missouri to Fort Benton, and on the Yellowstone, where it is most extensively developed, to the month of the Big Horn River and collected great quantities of animal and vegetable remains from the base to the summit. Every season, up to the autumn of 1860, I made collections from this group in all parts of the Northwest.

The vertebrate remains were studied by Dr. Leidy; the vegetable fossils, by Dr. Newberry and Mr. Lesquereux; and the invertebrate fossils, by Mr. Meek and the writer. None of us even doubted their Tertiary age. Numerous papers were published by Mr. Meek and the writer on the geology and invertebrate paleontology of this region in various journals, but mostly in the Proceedings of the Academy of Natural Sciences at Philadelphia; and inasmuch as these articles are not easily accessible to the general public, I shall be excused from quoting paragraphs from them quite freely in an official report.

In an article published in the Proceedings of the Academy of Natural Sciences, May, 1857, we state that of the 150 species of Mollusca already described, 54 species are of Tertiary age, 50 are strictly fresh-water, and only four belong to genera supposed to inhabit salt or brackish waters. This group was even regarded as of Miocene age. The first conclusion, at the close of this paper, reads as follows:—"We have no evidence that any of the Tertiary deposits now known in Nebraska are older than Miocene."

The above paragraph shows that Mr. Meek and the writer attempted to correllate the various Tertiary groups in the Northwest in the light of the knowledge they possessed at that time.

But it was from the very abundant fossil flora of this group that the most positive proof of its age was derived. It is hardly possible to estimate with accuracy the thickness of this great group in the Northwest, but I should regard it from 3,000 to 5,000 feet in the aggregate, with from twenty to thirty beds or seams of lignite, not including the thin seams of an inch or two, which are very numerous. These vary from six inches to ten feet in thickness. All through this great thickness of strata, the leaves are found in most instances in a remarkably perfect state of preservation. Sometimes they are so abundant and so perfectly preserved that they would appear to have fallen from the trees on the spot and in the greatest profusion. It is not uncommon for a stratum of two feet or more to be composed almost entirely of these leaves, lying parallel with the layers, as if they had not been disturbed after dropping from the trees. Along the immediate vicinity of the main rivers (Missouri and Yellowstone), these plants are the most abundant, far more so than in the more important coal-regions of Wyoming or Colorado.

Although my own collections, made from 1850 to the autumn of 1860, doubtless comprise the greater part of the species that will hereafter be found, and therefore form a permanent basis for determination and comparison, yet the force of their teachings is somewhat weakened from the fact that the species from different horizons were not kept sufficiently separate. We know, however, that some of the species have a very great vertical as well as horizontal range, and that, so far as can be detected, there is no break in the sequence of the beds from the Saskatchewan to Santa Fé.

The following extract is taken from a paper prepared by Mr. Meek and the writer, and published in the proceedings of the Academy of Natural Sciences, Philadelphia, December, 1861. This extract will not

only serve to show the views we entertained at that time after : study and discussion of the invertebate fossils, but incident opinions of other eminent paleontologists:

"It would extend these remarks beyond the limits assigned t attempt any detailed account of the Tertiary rocks of Nebrask discuss at length the question respecting their relations to those Atlantic coast, or of the Old World.

"We must, therefore, limit ourselves here to a few brief stateme leading facts, and leave all details for another occasion.

"In the first place, we would remark, that no strictly marine Te deposits have yet been discovered in all the Rocky Mountain regi *Nebraska, nor, so far as known, in any other portion of Nebr Kansas, or Utah.

"Throughout all this great central area of the continent, whereve oldest Tertiary deposits have been seen, they give evidence of fresh brackish water origin, and, where observed resting upon the most rec Cretaceous beds, the two have been found conformable, and sometim blended together, so as to render it difficult to draw a line between the in the absence of organic remains. All the facts indicate a gradua change from the marine conditions of the Cretaceous; at first to brackish, and then to the fresh-water conditions of the Tertiary. The predominance of *Gasteropoda* and *Lamellibranchiata*, and the comparative paucity of types usually considered characteristic of deeper-water deposits, as well as the coarser nature of the sediments, near the end of the Cretaceous epoch of this region, indicate that the waters were growing more shallow as the land on the east encroached on the sea, and islands were rising where the Rocky Mountains now stand, while the close of the Cretaceous period seems to have been attended by the gradual elevation of large areas of country here above the ocean-level. This and other contemporaneous changes of physical conditions caused the total destruction of the whole Cretaceous fauna.

"After this, extensive tracts of country in the region of the Rocky Mountains, and east of them in Nebraska and other northwestern Territories, were occupied by bays, inlets, estuaries, etc., of brackish water, inhabited by Mollusca of the genera *Ostrea*, *Unio*, *Pisidium*, *Corbicula*, *Potamomya*, *Melania*, *Melampus*, *Vivipara*, etc., all of Tertiary types. As the gradual elevation of the country continued, the salt and brackish waters receded and gave place to lakes and other bodies of fresh-water, in which most of the Tertiary rocks of the Northwest were deposited; so that in all, excepting the earliest Tertiary beds of this region, we find only the remains of strictly fresh-water and terrestrial animals.

"The passage from the brackish to the fresh water beds in the oldest member of the Tertiary of this region seems not to be marked by any material alteration in the nature of the sediments. Nor have we, so far as is yet known, any reasons for believing that any climatic or other important physical changes, beyond the slow rising of the land and the consequent recession of the salt and brackish water, took place during the deposition of the whole of the oldest member of the Tertiary here, since we find a considerable portion of the species of fresh-water Mollusca ranging through this whole lower member.

"The principal difference between the fossils of its upper and lower beds consists of the gradual disappearance of strictly brackish-water types as we ascend from the interior strata. The entire series of Ne-

* The old Territory of Nebraska is here referred to.

braska Tertiary rocks consists of three or four groups, three of which at least (and probably four) evidently belong to separate and distinct epochs. They usually occur in isolated basins, but have, with one exception, all been seen in such connection as to leave no doubt in regard to their order of superposition.

"Their prevailing lithological characters, estimated maximum thicknesses, and order of succession will be seen in the section given below.

Names.	Subdivisions.	Thickness.	Localities.	Foreign equivalents.
Loup River beds.	Fine loose sand, with some layers of limestone; contains bones of *Canis*, *Felis*, *Castor*, *Equus*, *Mastodon*, *Testudo*, etc., some of which are scarcely distinguishable from living secies.	300 to 400 feet.	On Loup Fork of Platte River, extending north to Niobrara River, and south to an unknown distance beyond the Platte	Pliocene.
White River group.	White and light drab clays, with some beds of sandstone and local layers of limestone; fossils, *Oreodon*, *Titanotherium*, *Chœropotamus*, *Rhinoceros*, *Anchitherium*, *Hyaenonodon*, *Machairodus*, *Trionyx*, *Testudo*, *Helix*, *Planorbis*, *Limnæa*, petrified wood, etc., etc. All extinct. No brackish-water or marine remains.	1,000 feet or more.	Bad Lands of White River, under the Loup River beds on Niobrara, and across the country to the Platte.	Miocene.
Wind River deposits.	Light gray and ash-colored sandstones, with more or less argillaceous layers. Fossils, fragments of *Trionyx*, *Testudo*, with large *Helix*, *Vivipara*, petrified wood, etc. No marine or brackish-water types.	1,500 to 2,000 feet.	Wind River Valley, also west of Wind River Mountains.	(?)
Fort Union or Great Lignite group.	Beds of clay and sand, with round ferruginous concretions, and numerous beds, seams, and local deposits of lignite; great numbers of dicotyledonous leaves, stems, etc., of the genera *Platanus*, *Acer*, *Ulmus*, *Populus*, etc., with very large leaves of true fan palms Also, *Helix*, *Melania*, *Vivipara*, *Corbicula*, *Unio*, *Ostrea*, *Potamomya*, and scales of *Lepidotus*, with bones of *Trionyx*, *Emys*, *Compsemys*, *Crocodilus*, etc.	2,000 feet or more.	Occupies the whole country around Fort Union, extending North into the British possessions to unknown distances; also southward to Fort Clarke; seen under the White River group, on North Platte River, above Fort Laramie; also on west side of Wind River Mountains.	Eocene.

"The Fort Union, or Great Lignite group, occupies extensive areas of country in Nebraska, and has been seen beneath the White River group at several distant localities. It was evidently deposited in large bodies of water, which were at first brackish, and then gradually became fresh.

"The great number of fossil leaves, and numerous beds of lignite contained in it, clearly show that the shores of these ancient estuaries, lakes, etc., in which this formation was deposited, supported dense forests of large trees, and a growth of other vegetation, far exceeding in luxuriance anything now met with in these latitudes.

"Indeed, the presence of true fan palms, of large size, and the remains of the genus *Crocodilus*, as well as the affinities of the Mollusca found in these beds to southern forms, all point rather to the existence here of a tropical than a temperate climate during their deposition. In regard to the relations of this formation to known horizons in the Tertiary of the Old World, we scarcely feel prepared to express a very decided opinion.

"The difficulty in the way of drawing inferences bearing on this point from the remains of Mollusca found in these beds is that they, being fresh and brackish water types, bear little or no analogy to those of the

Tertiary of the States bordering on the Atlantic, nor are any of them, so far as known, specifically identical with foreign forms.

"When we bear in mind, however, the fact, that wherever this formation has been seen in contact with the latest Cretaceous beds, the two have been found to be conformable, however great the upheavals and distortions may be, while at the junction there seems to be a complete mingling of sediments, one is strongly impressed with the probability that no important member of either system is wanting between them. This view is also rendered more probable by the fact that the formation under consideration is known to hold a position beneath the White River group, which is characterized by the remains of an entirely different fauna, clearly of Miocene age.

"Again, the occurrence in this lower group of remains of the genus *Lepidotus*, which is, we believe, in Europe unknown above the Eocene, while the other vertebrate remains found associated with it have been compared by the distinguished comparative anatomist, Professor Leidy, with types even older than the Tertiary, are facts strengthening the impression that this Fort Union Lignite group probably represents the Eocene of Europe.

"It should not be forgotten, however, that an extensive and beautiful series of fossil plants from this formation, although not yet thoroughly investigated, have been thought by Dr. Newberry to be most analogous to Miocene types.

"Yet even if this formation should prove to be of Eocene age, this would only be in accordance with what is now known in regard to the earlier introduction of particular types of plants in the Cretaceous system of this country than in that of the Old World.

"As the Wind River deposits have not yet been seen in contact with any well-marked beds of the other Tertiary formations of this region, and few fossils have yet been found in them, their position in the series remains doubtful. It is, therefore, only provisionally that we have placed this formation between the Fort Union and White River groups in the foregoing section. It may possibly belong to the horizons of one of these rocks, or even represent them both in part, or, what is more probable, it may occupy an intermediate chronological position.

"The only fossils yet found in this formation are fragments of *Trionyx* and *Testudo*, together with the shells of two species of *Helix* and a cast of a *Vivipara*. One of these *Helices* is more like *H. Leidyi* from the White River group than any of the other species yet known from any of these rocks, while the other is a very large depressed species of southern type, quite unlike any of those hitherto found in any of the other Nebraska rocks. The *Vivipara* seems to be indistinguishable from our *V. trochiformis* from the Fort Benton group, though, as it is a mere cast, it cannot be identified with certainty with that shell. No marine or brackish-water fossils have been found in these beds. The White River group is the formation that has furnished the extensive and interesting collections of vertebrate remains which have been so ably investigated by Professor Leidy. It occupies a considerable area in the region of White River, and is seen beneath the succeeding formation on the Niobrara and Platte Rivers. Its position above the Fort Union or Great Lignite group has also been clearly and satisfactorily determined.

"This formation is mainly composed of a series of whitish, indurated clays, which have been worn and cut, by the streams, rains, and other atmospheric agencies, into numerous deep valleys and ravines, so as to leave various peaks, isolated columns, towers, etc., presenting, as seen

from a distance, exactly the appearance of the ruins of an ancient city. The difficulty the traveler meets with in finding his way through this interminable labyrinth caused the Indians to call it, in their own language, the Bad Grounds; hence the French name, *Mauvaises terres*, applied by the Canadian voyageurs in the employ of the fur-companies.

"The vertebrate remains found in these beds belong to the genera *Oreodon*, *Agriocharus*, *Pœbrotherium*, *Leptomeryx*, *Leptanchenia*, *Protomeryx*, *Merycodos*, *Titanotherium*, *Leptochœrus*, *Hyracodon*, *Entelodon*, *Palæochœrus*, *Rhinoceros*, *Steneofiber*, *Machairodos*, *Anchitherium*, *Hyopotamus*, *Hyænodon*, *Ischyromys*, *Palæolagus*, *Eumys*, *Testudo*, etc., etc. The affinities of these fossils, as has been shown by Professor Leidy, clearly establish the Miocene age of this formation.

"Comparatively few invertebrate remains have yet been found in the White River group. They consist of one species of *Helix*, one or two of *Limnæa*, a small *Physa*, two or three small species of *Planorbis*, etc. No fossil leaves nor beds of lignite have been met with in it, and all the animal remains, as may be seen from the foregoing list, are terrestrial and fresh-water types. The Loup River beds consist mainly of incoherent materials, and were evidently deposited after the upper surface of the White River group had been worn into ravines and other depressions. It occupies much of the surface of the country in the region of the Loup Fork and Platte River, and extends far south of the latter stream.

"The vertebrate remains from it described by Professor Leidy belong to the genera *Megalomeryx*, *Procamelus*, *Cervus*, *Rhinoceros*, *Mastodon*, *Elephas*, *Hipparion*, *Merychippus*, *Equus*, *Castor*, *Felis*, *Canis*, *Testudo*, etc., many of which are very closely allied to recent species. A few shells of the genera *Helix*, *Physa*, etc., apparently identical with living species, have also been found in these beds. All the species of vertebrate and other remains yet found in them are distinct from those occurring in the White River group and beds below, and they have not yet afforded any brackish or marine types of any kind.

"When we take into consideration the position of this formation above the well-marked Miocene White River group, and the relation of its organic remains to Pliocene and recent species, there is little room for doubting the correctness of its reference to the horizon of the Pliocene of Europe.

"The extracts which I have given are sufficient to show the opinions of a most excellent paleontologist in regard to the age of this group as interpreted from the invertebrate fossils."

Let us for a moment glance at the testimony of American vegetable paleontologists. Without quoting again, I will simply refer the reader to the interesting report of Dr. J. S. Newberry on the Cretaceous and Tertiary plants collected by me during the expedition to the Yellowstone and Missouri Rivers, during the years 1859 and 1860, a portion of which was reprinted in the Annual Report of Wyoming, 1870, commencing at page 94. It will be seen that Dr. Newberry regarded these fossil plants as not only of Tertiary age, but Middle Tertiary, or Miocene. In an interesting memoir published in the Annals of the Lyceum of Natural History, in 1867, Dr. Newberry remarks:

"By far the largest representation of our Tertiary flora is, however, contained in collections made by Dr. Hayden on the Upper Missouri, of which the greater number of species are described in the present memoir. These plants are from the lignites proved by the associated fossils to be of the Miocene age. They were collected at various points on the Missouri River, at Fort Clarke, at Red Spring, thirteen miles above, at Fort Berthold, at Crow Hills, one hundred miles below Fort Union, at

the mouth of the Yellowstone, on O'Fallon's Creek, one hundred miles above the mouth of the Yellowstone, and in the valley of that stream.

"The explorations of Dr. Hayden prove that this Miocene Lignite formation occupies the beds of extensive lakes, which formed basins on the surface of the continent when it had but recently emerged from the Cretaceous sea. As has been remarked elsewhere, the lower members of the series contain a few estuary shells, showing the access of salt-water at that period; but during the deposition of by far the greater portion of these beds, the water of the ocean was entirely excluded from the basins in which they accumulated. There is, therefore, every reason to believe that the *débris* of ligneous plants which compose this collection were derived from trees which grew along the shores of the lakes and streams of the Tertiary continent; that then, as now, alternations of seasons prevailed, by which the foliage of these trees were detached by an autumnal frost, and that falling into the water beneath or near them, and sinking to the bottom, they were enveloped in mud, precisely as leaves of our sycamores, willows, oaks, etc., accumulate at the bottoms of our streams and lakes of the present day."

I need not extend these remarks farther to illustrate the views of both paleontologists in regard to the age of the Lignitic group, as observed in the Northwest, up to within a comparatively recent period. I need not refer to the views of Mr. Lesquereux, inasmuch as they have been consistent in the belief of their Tertiary age, from the commencement of his examination up to the present time, and his arguments in favor of this belief have been set forth in nearly all the annual reports of the Survey.

If the Lignitic group, as developed on the Upper Missouri, is admitted to be either entirely or in part of Tertiary age, the question will arise, what bearing has this admission on the age of the coal-beds of Wyoming and Colorado?

I beg just here to call the attention of geologists to the geological maps prepared by me, and published in the Final Report of Nebraska, 1869, and in the Geological Report of the Exploration of the Yellowstone and Missouri Rivers, 1859–'60, especially the latter map. It will be seen by the last-named map that the Lignitic group occupies a very large area along the Upper Missouri and the Yellowstone Rivers, that it extends far north into the British possessions. We may then trace it southward in a broad continuous belt across the Yellowstone River, between the Black Hills and the Big Horn Mountains, until it is overlapped by the White River group, about sixty miles north of Fort Laramie. If we continue southward along the east base of the Laramie range, we find that the Lignitic group re-appears about ten miles south of the Union Pacific Railroad. We find that where the White River group and the Lignitic group come in contact, the former is superimposed on the latter, and that really the White River group formed a vast basin subsequent to the existence of the great lake in which the lignitic sediments were deposited. We find also, by examining the White River group along the base of the mountains, that the Laramie range formed a barrier that prevented it from extending into the Laramie Plains; but the evidence is clear that, at the time of the existence of the great Lignitic lake or sea, this barrier did not prevent the water-communication with the Laramie Plains. Indeed, the evidence seems quite clear that, with the exception perhaps of some isolated peaks rising above the waters, there was no mountain-barrier where we now have the Laramie range. Therefore, with the exception of the Bear River and Coalville group, we may connect the coal-bearing beds of the

Laramie Plains and Colorado with the vast group in the Northwest. I have traced this geographical connection step by step over this great area, have studied the formation with some care, and collected both vegetable and animal fossils in the greatest abundance from point to point. I would say, however, that comparatively few of the fresh-water species of Mollusca, so abundant in the Northwest, are found either in Colorado or the Laramie Plains; but it possesses the same character, and many of the same species of plants are scattered all over this immense area.

CHAPTER II.

THE LIGNITIC GROUP AS EXAMINED AT CANON CITY—COLORADO SPRINGS—NORTHWARD TO CACHE LA POUDRE CREEK—MONUMENT CREEK GROUP—PROBABLE AGE OF THESE GROUPS.

Our examinations along the eastern base of the mountains in Colorado were directed mainly to the tracing-out of the connection between the Lignitic group and the older beds. We traced the boundary of this group, with great care, from Cañon City, on the Arkansas River, northward nearly to Cheyenne. It is hardly possible that any links in the chain of evidence escaped us, and the principal differences of opinion now will consist in the degree of importance to be attached to that evidence. The question is whether the coal-bearing strata known as the Lignitic group of the Eastern Rocky Mountain region is of Cretaceous or Tertiary age. In this chapter, we shall simply record our field-observations, referring the reader to a subsequent chapter for a brief discussion of the question of age.

South of Cañon City, on the south side of the Arkansas River, there is an isolated coal-basin occupying an area of about fifty square miles. The strata lie for the most part in a nearly horizontal position, indicating no great disturbance, except along the north and west sides. On the northwest side of the basin, along the immediate base of the mountains, the beds have been lifted up, so that a great thickness of the Lignitic sandstones is exposed, at least 1,000 to 1,500 feet. The Cretaceous beds are also seen lying close to the flanks of the mountains. As we proceed southward along the junction of sedimentary beds and the granites, the Cretaceous beds disappear, and one by one the lower Lignitic, until the whole mass juts against the granitic rocks, with no perceptible evidence of disturbance, except in a general way. There seems to be a rapid slope from the base of the mountains to the Arkansas River, a distance of about five miles, thus giving to the strata a general dip of about 5°. So far as we could ascertain, there are no coal beds in the northern portion of the basin. The rocks consist mostly of rather thick beds of gray, brown, and yellow sandstone, with loose clays and sands between, but no coal-beds. We find that the coal-bearing portion does not occupy the entire area, and that a large part is classed as barren coal-measures. The most important coal-mine has been opened on the east side of the basin, about midway, on Oak Creek. This is one of the most important coal-mines in the Territory. It was described briefly, but quite clearly, in the Annual Report of the Survey for 1869, and since that time in the more elaborate reports of Mr. Lesquereux. In the summer of 1872, Mr. Lesquereux made a careful examination of the coal-formations all along the east base of the Rocky Mountains from Cheyenne to Santa Fé. His report in the Annual Report for 1872 is quite exhaustive. The section of the coal-strata on page 323, made by Mr. Neilson Clark, the superintendent of the mines, is more accurate than any other that has been made of the group, and need not be repeated here. It remains now to consider the beds below this sec-

ion, which are supposed to be of Cretaceous age, but which might very properly be called beds of passage from well-marked Cretaceous strata to those containing coal and vegetable remains. We have heretofore described the Upper Cretaceous beds as of strictly marine origin; that the sediments were deposited in a broad and, at least, moderately deep sea. As long as we find that these physical conditions prevailed, we observe a greater or less abundance of fossils of strictly marine forms, as *Ammonites*, *Baculites*, *Inoceramus*, *etc.;* but even when no break can be found in the sequence of the beds, indicating a lapse of time in the deposition of the sediments, we discover that the physical conditions gradually change until there is a complete extinction of all marine forms of life. We find here on the Arkansas River a full development of the Upper Cretaceous formations Nos. 4 and 5, with their peculiar fossils. We also observe that the materials of the upper portion of No. 5 pass gradually from a dark-yellow clay to a rusty-yellow sand, and above this, 200 to 300 feet, of a sort of irregular thin layers of mud-like material, with curious concretions of sandstone. In this group of strata, which may be called transitional, not a fossil has yet been found to prove the age beyond a doubt. Resting on this irregular group of mud-strata is a bed of sandstone of very variable thickness as well as structure. Sometimes it is not more than 50 feet thick, and then again it is 300 to 400 feet thick. It is full of rounded concretionary masses, and shows very clearly that its sediments were deposited in shallow and very turbulent waters. This sandstone passes up into clay, and on this clay rests a bed of coal. In the bed of sandstone below the coal, the peculiar vegetation of the Lignitic group is found in considerable abundance, and, therefore, this may mark the lowest horizon of this group. Now, whenever, in any part of the country, invertebrate remains of any kind are found above this bed of sandstone, they are invariably brackish or fresh water in their character; and whenever any of these fossil shells are observed below this sandstone, they are always strictly marine. We have in the vicinity of these coal-mines the details of structure, which we have briefly described above, most clearly shown. Now the question arises, what stress shall be laid on these remarkable physical changes? Would not this form an excellent line of separation between two great periods in geological time? Are not these changes sufficient to indicate clearly that these are probably the beds of passage or transition between the Cretaceous and the Tertiary epochs? We find also a complete change in the vegetable as well as animal life. We are not aware that any of the vertebrate remains, which have been regarded by Cope and Marsh as proving the Lignitic group to be of Cretaceous age, have ever been found mingled with any other forms of life of strictly marine origin. So far, all the vertebrate fossils have been discovered in the Lignitic group. It seems therefore that not a single species of vegetable or animal life survived the physical changes which were introduced during the time of the deposition of the transition group. Now, if we have shown this state of affairs in regard to the Cañon group, we may connect this group easily with the Raton Hills group to the southward, and the Monument Creek group far to the northward near Colorado Springs.

In passing northward, we see no more of the Lignitic group, so far as we have examined, until we reach Colorado Springs, a distance of thirty miles in a straight line. Here it is exposed in the form of an irregular bluff ridge, running down from the base of the mountains a little southeast, beyond the limit of our explorations up to this time. In section 2, we see in the foreground, at either end, the form of the sandstone bluffs, which appear to be remnants of a far more extended group of strata.

The inclination is slight, 5° to 10°, about; northeast. The bluff-wall undoubtedly extended at one time over the entire interval south and southwest and was joined to the Cañon City group; the intervening portions having been removed by erosion, with the exception of a narrow belt just at the base of the mountains. This interval is entirely occupied with Cretaceous rocks at the present time. The valley of the Fountain, as well as that of Monument Creek, for some distance above its junction with the Fountain, is underlaid with Upper Cretaceous groups Nos. 4 and 5; but the surface is everywhere so denuded and grassed over that the junction of the Cretaceous with the Lignitic group is nowhere well marked.

The lower bed of sandstone, which is usually regarded as the commencement of the Lignitic, is composed sometimes of yielding arenaceous sediments, and therefore cannot always be relied upon as forming a fixed horizon of demarkation. But, in the majority of instances, this floor of sandstone is present with a greater or less thickness. About ten miles east of Colorado Springs, some very important coal-beds have been opened by Mr. Matt France and others. This locality is a very important one for the study of this great coal-group. Between Colorado Springs and the coal-mines, the intervening country is very rolling or undulating, and so grassed over that no sections of the underlying beds are exposed; but, before reaching the mines, the rounded grassy hills are covered with fragments of calcareous concretions, from which have been taken a great variety of the fossils characteristic of the Upper Cretaceous. The three forms which are usually so abundant, *Ammonites lobatus*, *Baculites ovatus*, and *Inoceramus*, are here found in great numbers. This point is about 600 feet higher than Colorado Springs; and inasmuch as the strata are horizontal, we may estimate the thickness of the Cretaceous beds above the valley of Monument Creek at 600 to 800 feet. As we continue to the west we soon come to dark, rusty-brown sandstones, with great numbers of a peculiar kind of sea-weed, called by Mr. Lesquereux *Halymenites*. There is a series of alternate layers of arenaceous clay and sandstones, 200 feet or more in thickness, the upper portion containing vast globular concretions, as illustrated in Plate 4, Fig. 2, which correspond to the mud-beds seen in the vicinity of the coal-basin of the Arkansas. A section of the beds here would be as follows, in ascending order:—

SECTION *a*.

	Ft.	In.
1. Coal	8	0
2. Clay	6	0
3. Sandstone	7	0
4. Clay	16	2
5. Yellow sandstone	5	0
6. Solid coal	8	1
7. Rusty-brown clay and sandstone	50—80	0
8. Alternate layers of sandstone and clay	200	0
9. Cretaceous formations Nos. 4 and 5	600—800	0

This section is in part constructed from shafts that have been sunk for coal. So far as I have observed, the only way to obtain a clear section of the coal-strata, is by boring or sinking a shaft. All other sections, unless made in some actual cut, may be regarded as only approximately correct. The lower portion of section *a*, Cretaceous, gradually passes up into bed 8, which is composed at the bottom of alternate thin layers of sandstone and clay, these layers increasing in thickness toward the top. The upper portion is made up mostly of rounded concretions, varying in size from an inch or two to sev-

Plate '.

1 ←—— 20 feet ——→ 2

Showing the variability of the Lignitic beds.

Parallel sections taken on the face of Pulpit Rock 5 miles north of Colorado Springs through identical strata and only 20 feet apart.

eral feet in diameter. Sometimes these concretions are oval or flat, with horizontal layers; but in most cases they fall in pieces, showing concentric coats, the disk-like shells falling off from the outside gradually. There is also a species of sea-weed, *Halymenites*, quite abundant in these sandstones. I call them the transition beds, though they may be Cretaceous, and they correspond with those described as occurring below the coal on the Arkansas.

Number 7 in the section is the sandstone that usually forms the basis bed of the Lignitic group. This bed is here full of small iron-rust concretions, some of them solid, with a gray nucleus, others hollow, the cavity filled with fine dust, a kind of iron-rust. These concretions, varying from an inch to three or four inches in diameter, are so abundant that they cover the ground for some distance from the bluff. About the middle of the sandstone-bed, there is a band of dark-brown indurated sand, mixed with bits or fragments of vegetable material, about five feet in thickness. This bed or band may, quite possibly, become coal in some localities. At one point in the southern portion of the coal-basin on the Arkansas River, a seam which appears to correspond to this dark band occurs in the lower sandstone, and is quite good coal, two feet in thickness. The quantity and character of the coal at this locality was determined by the sinking of several shafts. In section *a*, we have two quite thick beds of coal, both of which were penetrated by a shaft, and thus the section may be regarded as correct.

SECTION *b*.

	Feet.
1. Surface-soil	8
2. Sand	12
3. Drab-clay	6
4. Soapstone and clay	9
5. Slate	5
6. Sandstone	4
7. Arenaceous clay	7
8. Soft slate	6
9. Coal	1
10. Sandstone with plants	30
11. Bituminous shales	11
12. Sandstone with iron	3
13. Clay	6
14. Hard black slate	11
15. Coal	6

In section *b*, which is the record of a shaft sunk at a distant locality in the same basin, we have only the upper bed of coal at the base. The two sections give a pretty clear idea of the strata which include the two lower beds of coal. Above the coal-bearing portion, there is an interval which we estimated at about 200 feet, in which the beds were obscure, but thin seams of impure coal cropped out. The materials were clays, arenaceous clays, and thin layers of sandstone, yielding so readily to atmospheric forces that no sharp bluffs are formed, so that the character of the strata could not be clearly seen. We then have a range of high bluffs 200 to 400 feet high, which begin at the base of the mountains, about two miles north of Manitou, and extend across Monument Creek, and reach off to the southeast far beyond the limit of vision, down the entire valley of the Fountain to its entrance into the Arkansas River near Pueblo. The rocks all around Pueblo are Cretaceous, yet it is quite possible that far to the eastward the Lignitic group overlaps them, having originally been connected with the coal-basin to the south near Cañon City. We may thus obtain a dim conception of

the vast erosion that must have taken place here, to have removed so great a thickness of strata from so vast an area.

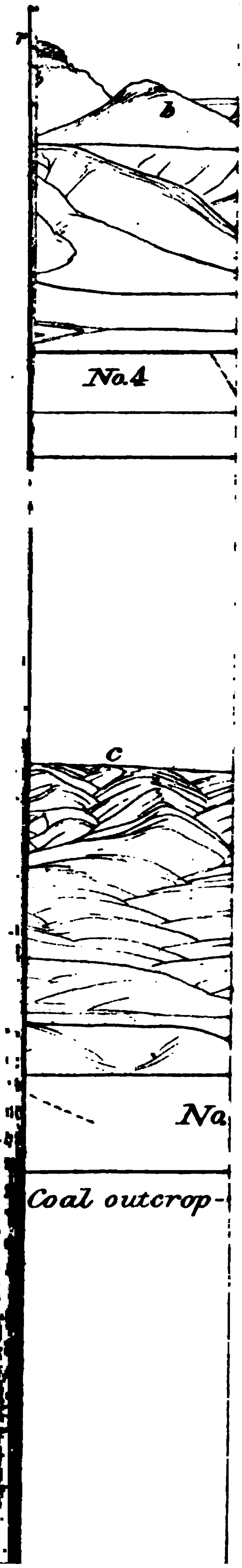
The bluffs east of Colorado Springs, above that portion shown in Sections *a* and *b*, may be regarded as barren of workable beds of coal. A detailed section of the beds was taken, but it seems hardly necessary to present it here. So variable are these beds that the sections within a fourth of a mile would only bear a general resemblance to each other.

The beds are made up of alternate layers of clay and sand, with irregular beds of concretionary sandstone throughout. These beds of sandstone change constantly, sometimes 30 feet in thickness, and quite massive at one point, and within a fourth of a mile either thinning out or changed into soft or indurated sand. Toward the summit of the bluff is a thick bed of rusty-brown sandstone, which has been worn by the atmosphere into remarkably rugged forms. As we proceed northwa from Colorado Springs to the source of Monument Creek, on the divi between the South Platte and the Arkansas drainage, the upper be of the Lignitic group appear entirely destitute of coal, with a vast thic ness, estimated at 1,500 to 2,000 feet, with unusually coarse sedimen The materials composing these Upper Lignitic strata of the Monume Creek present the appearance of having been deposited with unusu rapidity in moving or disturbed waters. Figures show with gre clearness this peculiar character of the sediments. The peculiar gro of strata which, in 1869, I called the Monument Creek group, extends a point within about twenty miles of Denver, where the Lignitic sed ments return to their usual character, and then continue northwar nearly to Cheyenne.

For a distance of about thirty miles north of west of Monument Cree the coarse variegated sandstones of the Monument Creek group lap o to the granites, have been slightly elevated so as to incline 5° to 15 but not detached from the granites, so that for a considerable distan these granite foot-hills formed the western shore-line for the great lak This group is more fully treated in a subsequent portion of this chap ter.

Up to the present time, but few invertebrate remains have been foun in the Lignitic group from the Arkansas to Denver; but in the low strata in the vicinity of the coal-beds a number of plants have be observed, belonging in most instances to well-known species occurrin elsewhere. These plants were observed by the Survey in several loca ties along the southern border of the group, generally in the bed of san stone immediately below the lowest coal, and ranging up 100 to 150 fe The species, as identified by Lesquereux, are *Sabal Campbelli*, *Plata Haydeni*, *Ficus tilliæfolia*, *Dombeyopsis obtusa*. The *Sabal* has be found at Raton Hills, Golden City, Black Buttes, and on the Upp Missouri River near Fort Union. The *Platanus* occurs at Rat Hills, Golden City, Black Buttes, and was originally described from t Upper Missouri River, where it is found in great numbers. The *Fic* has been obtained from Evanston on the Union Pacific Railroad, Rat Hills, and in Montana on the Yellowstone, so that the evidence, so f as it can be derived from the few vegetable remains, connects this gro with the Raton Hills group to the southward, and far to the north the Upper Missouri. Other species have been identified.

From Colorado Springs, we may follow the Lignitic group northwa very nearly to Cheyenne without any break. For a short distance, we have previously remarked, the Monument Creek group laps on to t granites, entirely concealing all older formations; but very soon aft crossing the "divide" to the drainage of Plum Creek, the older beds r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Coal outcrop-

appear in the form of uplifted ridges. This belt, though varying much in width, is not again interrupted until we reach a point within a few miles of the Union Pacific Railroad, west of Cheyenne. Sometimes this belt extends out from the mountain foot-hills four or five miles, and again it closes up so that the Lignitic bed, as at Golden City, extends up to within one-fourth or one-half a mile of the granites.

I need not describe again the geological features of the district about Golden City, so much has already been written, nor need I repeat the fifty or sixty species of fossil plants which have already been detected in this far-famed locality. On the map which accompanies this report, the boundary-line between the Lignitic group and the well-marked Cretaceous strata is shown very clearly. We may say that very soon after leaving the granite foot-hills, the Lignitic beds, at whatever angle they may be found to incline, return to a nearly or quite horizontal position. We may say that they incline at all angles from 5° to 70°, depending upon their distance from the base of the mountains.

From Colorado Springs to Golden City, the outcrops of the coal are very rare; but, from Golden City to the Big Boulder, they are quite common, and the most productive coal-mines in Colorado are found there. That beds of lignite or coal underlie the plain country far to the east, there is hardly room to doubt. About ten miles east of Denver, on the Kansas Pacific Railroad, at a locality called Tousland, several shafts have been sunk in the level prairie, and a thick bed of coal or lignite was found at moderate depths.

A section of the strata is as follows:—

1. Clay, gravel, etc.
2. Soft sand-rock .... 10 to 12 feet.
3. Sandstone, with seams of coal varying from 1 to 18 inches in thickness, with 6 to 8 inches of sandstone between .... 30 feet.
4. Coal or lignite .... 6 feet.
5. Sandstone, forming the floor of the mine.

This is one of the most elaborately and elegantly prepared mines in Colorado Territory; but the coal contains so large a percentage of volatile matter that it will probably not be made available for economical purposes until the more valuable coal-mines in the vicinity are exhausted. The great scarcity of timber all over this portion of the West may, at some future day, render any kind of combustible material valuable as a fuel. One shaft sunk here is 245 feet deep, and a second one, about a mile distant, is 145 feet deep. Both of them passed through this 6-foot bed. The strata are horizontal. This bed is probably higher up in the series than any of the beds that are wrought near the base of the mountains. A few impressions of deciduous leaves were observed here, but no other fossils of any kind.

Again, near Platteville, on the line of the Denver Pacific Railroad, north of Denver, we find that several shafts have been sunk for coal near the outer border of the group. About a mile south of Platteville, a shaft was sunk 32 feet through the following strata, descending:—

1. Clay .... 8 feet.
2. Seam of impure coal .... 1 foot 6 inches.
3. Hard sandstone .... 10 feet.
4. Blue quartzitic sandstone .... 1 foot 2 inches.
5. Black carbonaceous clay, as roofing .... 5 feet.
6. Coal .... 2 feet.
7. Black clay, as a floor.

The Hopkins mine is about a mile and a half east of Stoner's. Here the shaft was sunk 65 feet. The mine is now abandoned. About two

miles northeast of Platteville, two industrious miners have sunk shafts in two places. The first one passes through the following beds, from the surface:—

1.	Yellow sand-clay	42 feet.
2.	Clay or soapstone, with 3 inches of a black material and called by the miners smut	2 feet.
3.	Clay	4 feet.
4.	A bed of shells	3½ feet.
5.	Clay	6 inches.
6.	Dark sand	1½ feet.
7.	Sandstone, yellow and gray	10 feet.
8.	Clay	4 feet.
9.	Coal	2½ feet.
10.	Clay-shale	4 inches.
11.	Fine sandy clay	2 feet.
12.	Coal.	

Forty-eight feet from the surface, the workmen came to a remarkable bed of shells. Masses were thrown out upon the surface 18 inches in thickness, a mere aggregate of shells. *Anomia*, and the same species of cyrenoid or brackish-water shells, found over a workable bed of coal at Hallville, on the Union Pacific Railroad, have been identified. About 300 yards from the last shaft, a second one was sunk 52 feet, passing through a bed of coal 29 inches thick, which is being wrought with great industry and some profit. These mines are just on the east border of the South Platte, while on the west side the Upper Cretaceous beds are exposed. Thin remnants of the Lignitic strata may occur on the west side, but no trace of coal in that immediate vicinity. We may, therefore, reasonably infer that this thin bed of coal near Platteville lies very near the base of the Lignitic series.

The next locality which we may mention is still farther to the northward, about ten miles to the northeast of Greeley, called Higley's mine, on section 20, township 6, range 66. The mine is opened in the level prairie, thirty miles east of the base of the mountains. The shaft passes through horizontal layers as follows:—

1.	Arenaceous clay.	
2.	Hard bluish quartzitic sandstone	2 feet.
3.	Clay	4½ feet.
4.	Coal	2½ feet.
5.	Floor of sandstone.	

A few fragments of leaves were observed in the hard sandstone, but no other fossils. Shafts have been sunk in many other places east of Greeley, but only thin beds of rather poor coal were detected. It is not probable that any valuable beds of coal will ever be discovered in the immediate vicinity.

Our examinations of the country between the South Platte and the base of the mountains, especially along the valley of the Cache à la Poudre, were productive of most important results. We found in an extensive series of sandstones, sands, clays, etc., a great variety of marine invertebrate fossils belonging to well-known Cretaceous types. The rocks are all quite peculiar, indicating by their structure that these depositions took place in moving waters. A few of the shells were found in the clays, and many of them were inclosed in dark, round, calcareous concretions, scattered through the clay; but most of them occur in isolated groups on the under or upper surface of a layer of sandstone, as if they had been swept into eddies or shallow depressions. As we have often stated, the physical history of these massive formations is written on the rocks themselves.

Fig. 1.

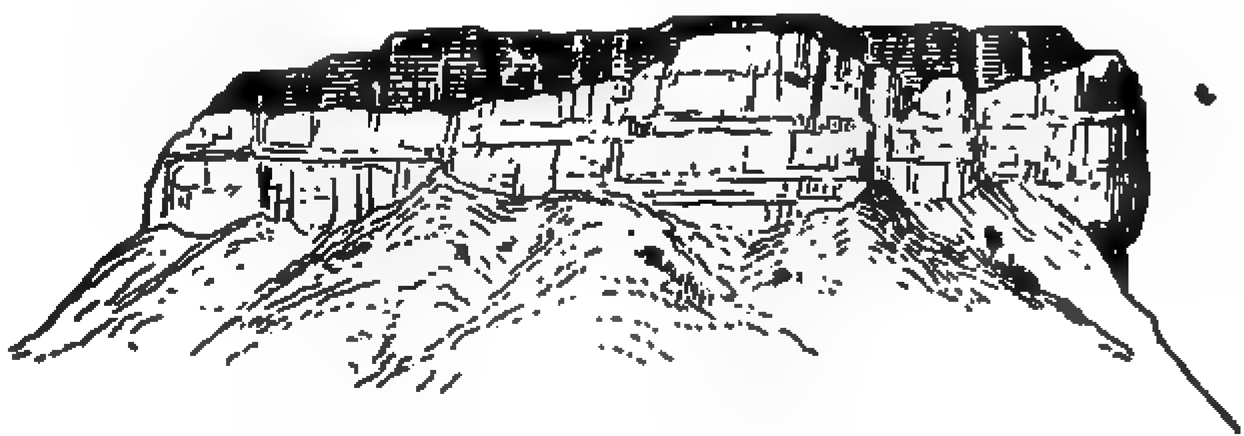

Table Butte capped with Trachyte 5 miles north of the Arkansas and Platte River divide.

Fig. 2.

a *Sandstone.* b b *Fire clay.* *Lignite.*

Deposit of Lignite in an irregular cavity in sandstone

In the lower portion of Cretaceous No. 5, or the Fox Hills group, the sediments all show a moderately deep sea and quiet waters, in which the various forms of Mollusca peculiar to this group flourished in great abundance, and have been preserved with wonderful perfection. But as we pass upward, we begin to observe signs of a gradual change to shallow and even turbulent waters. Tracks and trails of worms, etc., are seen on the surface of the thin layers of sandstone, and the more massive sandstones become concretionary, irregular, sometimes quite thick, and then suddenly thinning out so as to be unimportant or entirely absent. While many of the species peculiar to No. 4 as well as No. 5 continue to flourish to a certain extent, new forms are introduced, such as *Tancredia americana*, *Cardium speciosum*, *Mactra formosa*, *Mactra alta*, and many others, previously known to occur in no other locality in this country except near the mouth of the Judith River on the Upper Missouri. There are also mingled with them *Baculites*, *Ammonites*, *Inoceramus*, etc., forms well known in the Fox Hills group all over the West. We may continue our way northward to Cheyenne, and from thence to the Missouri and the Yellowstone region to the north line of the United States, and we shall find the Lignitic group remaining substantially the same and bearing similar relations to the Fox Hills group below. In all this distance, the only break in the connection that occurs is a distance of about two hundred miles, between Cheyenne and the North Platte, where the Lignitic group is overlapped by the more modern beds of the White River group.

Our investigations in Colorado seem to warrant the following conclusions:—

1st. That through the upper portion of the Fox Hills group, there are clear proofs of a radical physical change, though very gradual, usually with no break in the sequence of time. In this portion of the group are well-marked Cretaceous fossils of purely marine types, and no others.

2d. That above the upper Fox Hills group, there are about 200 feet of barren beds, which may be regarded as beds of passage to the Lignitic group, which more properly belong with the Fox Hills group below. In this group of transition beds, all trace of the abundant invertebrate life of the great Cretaceous series below has disappeared.

3d. In almost all cases we find at the base of the true Lignitic group a bed of sandstone, very irregular in thickness and structure, which seems to mark the horizon or dawn of this group. In this sandstone, the first deciduous leaves peculiar to this group occur. No purely marine Mollusca pass above this horizon. Estuary or brackish-water shells are found in many localities in great abundance. These soon disappear, and are succeeded farther north by fossils of purely fresh-water origin.

Whatever view we may take in regard to the age of the Lignitic group, we may certainly claim that it forms one of the time-boundaries in the geological history of our western continent. It may matter little whether we call it Upper Cretaceous or Lower Eocene, so far as the final result is concerned. We know that it plays an important, and, to a certain extent, an independent part in the physical history of the growth of the continent. Even the vertebrate-paleontologists, who pronounce with great positiveness the Cretaceous age of the Lignitic group, do not claim that a single species of vertebrate animal passes above the horizon I have defined from the well-marked Cretaceous group below.

Having presented these facts as briefly and clearly as we were able, we will leave the further discussion of the age of the group to a future period.

MONUMENT CREEK GROUP.

On the high divide between the drainage of the Arkansas and South Platte Rivers, we find a somewhat singular formation, differing in some respects from any other that we have met with in the West. The sediments were undoubtedly deposited in a rather modern fresh-water lake; but whether we can synchronize this group with any of the other lake-deposits in the West remains yet to be discovered.

This group was named by me in 1869 the Monument Creek group, from the fact that the atmospheric agents have carved out of some of the beds a very peculiar kind of monument, or columns, which long ago attracted the special attention of the traveler. These columns have given name to a small stream, which rises in the divide, and flows south into Fountain Creek, also to a very interesting locality now known as Monument Park, in the valley of West Monument Creek, where these singularly-shaped columns do most abound. These singular columns have been frequently described in previous reports of the Survey; but the accompanying figures on Plate 3 presents them to the eye in their varied forms far more clearly than any description in words.

The boundaries of this basin have not yet been determined, but it is believed that it does not occupy a very large area, probably confined to the high ridge or divide which seems to give origin to so many small streams, which, as seen on the map, flow south into the Arkansas River. In this basin, Beaver, Kiowa, Bijou, Box Elder, and Cherry Creeks, branches of the South Platte, take their rise; while to the south, many branches of the Fountain and Chico take their origin, and flow far southward into the Arkansas. With our present knowledge, we may estimate the area approximately as about forty miles from north to south and fifty from west to east, or about two thousand square miles. It is plain that it originally extended over a much larger area; the evidences of denudation by which large portions have been removed being apparent all around its borders. The basin itself lies in the Lignitic group. All around its south, north, and east borders, we find the beds of this group cropping out, while on the west side they are exposed, when not concealed by the nearly horizontal beds of the more modern group. Except along the base of the mountains, it is not easy to detect any want of conformability in the connection of the two groups; and this relation is obscure, when the older beds are lifted up at the base of the granite hills, on account of the great amount of local drift, which seems to cover everything to a considerable thickness.

The texture of the rocks of this group is quite varied. The aggregate thickness is probably about one thousand five hundred feet. The lower portion is composed of rather massive beds of sandstone, varying from a puddingstone to a fine-grained sandstone, usually of a light color, sometimes yellow or iron-rust, with their intercalations of arenaceous clay. In the distance, the whole group presents a chalky-white appearance in many localities. At the immediate base of the mountains, just south of the small lake on the divide, the rocks are variegated sandstones, brick-red, white, and yellow, varying in texture from a fine sandstone to a puddingstone, with all the signs of deposition in moving waters, and so closely resembling the older red sandstones, which we had usually regarded as Triassic, that I had no small difficulty in determining their exact position. Still farther north, on the divide proper, the beds jut against the granites, inclining not more than 3°, and are made up of a coarse aggregate of feldspar and quartz crystals, so that it resembles a very coarse granite. It is plain that the sediments of this group were

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derived very largely from the granitoid rocks. The sediments become finer and finer as we recede eastward from the foot of the mountains into the plains.

To the eastward of the line of the Denver and Rio Grande Railroad, the surface is cut up into more or less rectangular masses, with rather broad table-shaped summits, varying from four hundred to eight hundred feet in height. The sides are often very steep—almost inaccessible. At a remote period in the past, the erosion has been very great, carving out by an almost inappreciably slow process, these broad valleys, leaving these buttes here and there, composed of horizontal beds, to aid in forming some conception of the amount of denudation which has taken place. It is not possible at the present time to estimate the original thickness of this group, but we believe it to have been very much greater than the highest beds now existing would indicate. The summits of many of these buttes are capped with a greater or less thickness of a beautiful purplish trachyte, which must have ascended in the form of dikes from beneath and flowed over the surface. Much of the trachyte is a sort of breccia, composed of rather coarse sandstones, which must have been caught in the melted material. It is quite evident that these outflows occurred during the existence of the lake, though at a late period. As to the real age of this group, I am inclined to regard it as Miocene, perhaps Upper Miocene. The great Front or Colorado range was elevated much as it is at present, though it rose some hundreds of feet during and perhaps since its deposition. Some of the lower beds of the group, though jutting up against the granitic mountain-sides, have evidently been lifted up several hundred feet above the same strata, far east on the plains. I think it might be synchronized with the upper portion of the White River group far to the northward, and is probably of the same age as the fresh-water deposits in the South Park, just over the range, which have yielded such an abundance of fossil leaves of plants, fishes, and insects. Up to this time, the Monument Creek group has yielded but few fossils, and those are vertebrates. Professor Cope states that, in the summer of 1873, he made a brief examination of this group for vertebrate remains, and he states that he discovered the hind leg and foot of an *Artiodactyle* of the *Oreodon* type. He also has every reason for believing that the fragment *Magaceratops coloradoensis* came originally from the same locality. He further believes the group to be of Miocene age, which was the conclusion of the writer in 1869. Professor Cope is disposed to regard the fresh-water strata in the South Park as newer than Eocene and probably Miocene.

I see no reason why they should not be of the same age as the Monument Creek group. The strata are horizontal, or nearly so, and hold about the same position in relation to the granitic rocks in the vicinity as the Monument Creek group. The sediments are quite different, it is true, and the fossil remains most abundant and varied in character. This condition might very well exist, inasmuch as we may suppose that the Front range entirely shut off all connection between them. Volcanic action seems to have been going on to a great extent during the deposition of the South Park beds, and a great portion of the sediments is composed of the eroded material of the igneous rocks.

APPENDIX TO CHAPTER II.

BY H. T. WEST.

Different strata passed through in boring for an artesian well by H. T. West, on section 12, township 5 north, of range 66 west, being in the county of Weld, in the Territory of Colorado—bore, 3 inches in diameter.

	Feet.	In.
Surface-soil	22	0
White sand-rock	7	0
Blue shale	7	0
Black shale	2	6
Coal	0	6
Brown rock	8	0
Hard brown rock (sandstone)	2	0
Brown rock	13	0
Hard brown rock	1	0
Soft brown rock	8	0
Blue shale	5	0
Hard white sand-rock	2	0
Blue shale	7	0
Hard blue shale	2	0
Blue shale	8	0
Hard blue shale	3	0
Blue shale	4	0
Hard blue shale	3	0
Blue shale	10	0
Rock	1	0
Blue shale	5	0
Hard blue rock	1	0
Blue shale	3	0
Rock	3	0
Rock (probably of a different character)	5	0
Hard rock	3	0
Blue shale	3	0
White rock	3	0
Gray rock	4	0
Blue shale	2	0
Hard rock	3	0
Gray slate	4	0
Blue slate	2	0
Gray slate	3	0
Rock	2	0
Blue shale	3	0
Hard slate; (I am doubtful may have been coal)	4	0
White sand-rock	5	0
Hard white sand-rock	3	0
Blue shale	4	0
Hard blue shale	2	0
Hard shale	3	0
Hard blue rock	5	0
Blue shale	1	0
	192	0

These memoranda were taken from the book kept by the man who did the boring. He saved samples of each stratum, but I think that they have been destroyed.

Higley's coal-mine is in section 20, township 7 north, of range 66 west. Mr. La Grange prospected for a company, of which I was the secretary, in sections 17 and 22, in the same township and range. He made a rough diagram of the results of his drilling (boring), which I have sent him, with the request that he perfect it and return to me, and when he does so I will dispatch it to you.

By the minutes which I kept, I find that he made a verbal report as follows, January 23, 1871:—

Mr. La Grange made a report of his operations in sections 17 and 22, with a rough diagram of his views in regard to the different strata of coal in these sections; also that the thickest vein of coal through which the drill had passed in boring in section 22 was 2 feet 7 inches.

On the 8th of February, 1871, he further reported—

That he had put down a series of borings in different sections to determine whether there were any large veins of coal to be found, and that he could find nothing thicker than three feet, the veins found varying from one to three feet.

That boring to the east of section 17, on section 22, he struck and passed through six different veins, none over 2½ feet thick.

He also stated—

That the coal seemed *softer* than that found on section 17.

That, in accordance with instructions, he had bored 51 feet on a section to the southeast, finding five different veins of coal, the lowest being the thickest, and that 2½ feet thick and softer than in section 17.

That he had also prospected to the west of the shaft sunk by our company on section 17, finding, at a depth of 27½ feet from the surface, a vein of good hard (for soft coal) coal; and further prospecting seemed to determine the fact of a rise in said vein to the west of two inches to the rod.

He further stated—

That he had thought it best, before cutting an incline (to shaft on section 17), to test the character of the coal and the profitableness of working it, by chambering, which had developed an inclination, or dip, eight inches in ten feet, which allowed the water to follow the work, thus rendering this mine unprofitable.

There seems to have been some convulsion of nature in that township, as will be seen from the fact that the Higley vein pitches in such a way as to drain the mine, while at our shaft, not forty rods north, it dips as stated.

CHAPTER III

RESUMÉ OF THE GEOLOGY ALONG THE EASTERN BASE OF THE FRONT OR COLORADO RANGE: SILURIAN, CARBONIFEROUS, TRIASSIC, JURASSIC, AND CRETACEOUS GROUPS.

The various groups of sedimentary rocks that occur along the eastern slope of the Front Range of Colorado from Cañon City to Cheyenne have been so often described in previous reports that it seems hardly possible to add anything further of importance. We will be able, therefore, to do little more in this connection than to describe, with some care, the maps, sections, and other illustrations which we have prepared f this report.

The "Preliminary map of the eastern base of the Rocky Mountain will be found to explain itself to a great extent. The topography given with much detail and in a picturesque form, so that the relatio of the sedimentary to the granitic rocks are admirably presented. T characteristic forms of the "Hog Back" ridges which have been often noticed, is clearly shown, as well as the *en échelon* features of t minor mountain-ranges as they run out into the plains.

The pictorial sections which accompany the map will serve to sho more clearly than we have hitherto done what we have denominat the plain and mountain districts, as well as the abrupt transition fro one to the other. The plain country extends uninterruptedly from t Missouri River to the base of the mountains. The elevation abov sea-level at Kansas City is 764 feet; at Denver, by way of the railroa 639 miles to the westward, the elevation is 5,197 feet; showing an aver age ascent of about seven (7) feet per mile over an apparently leve treeless plain. Over this broad space the strata are very nearly o quite horizontal in position, until within a few miles of the mountain where they are lifted up at various angles and the mountain-range seem to rise abruptly out of the plains. The topography as well as th geology of the plain country is remarkably simple, and it is only in a narrow belt along the immediate foot of the mountains that it become more varied and complex. The elevation of the great Front or Colorado range carried up the sedimentary formations which originally rested on its sides or summit, and the uplift seems to have been very nearly or quite vertical. Whether these formations originally extended uninterruptedly across the area now occupied by the mountain-ranges, is a question which will be more fully discussed at some future period. That this was the case in part, I am very confident, but there are facts that appear to disprove this statement in some instances. It seems probable that a portion of the Rocky Mountain range was outlined at an early period; that it has grown, as it were, through successive ages up to the present time. A careful examination of the map and the pictorial sections will enable the reader to understand more clearly the remarkable belt of uplifted sedimentary beds along the immediate base of the mountains. Although they seem to be more interesting and picturesque in Colorado, yet these ridges occur to a greater or less

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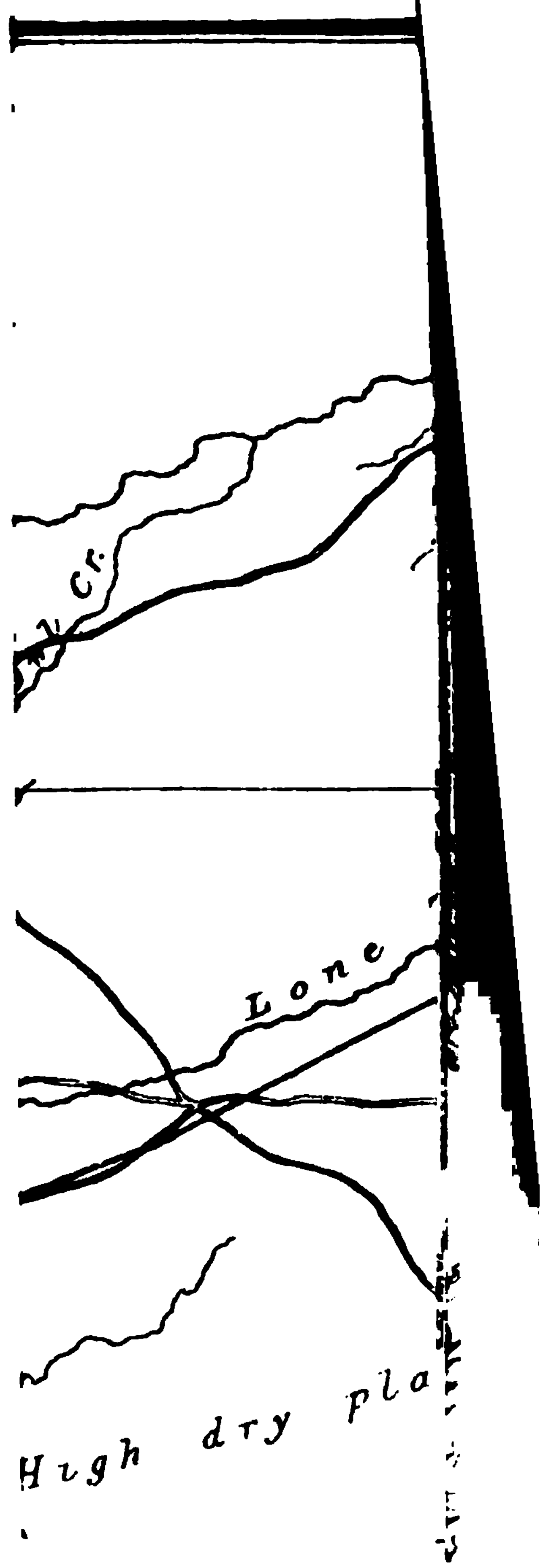
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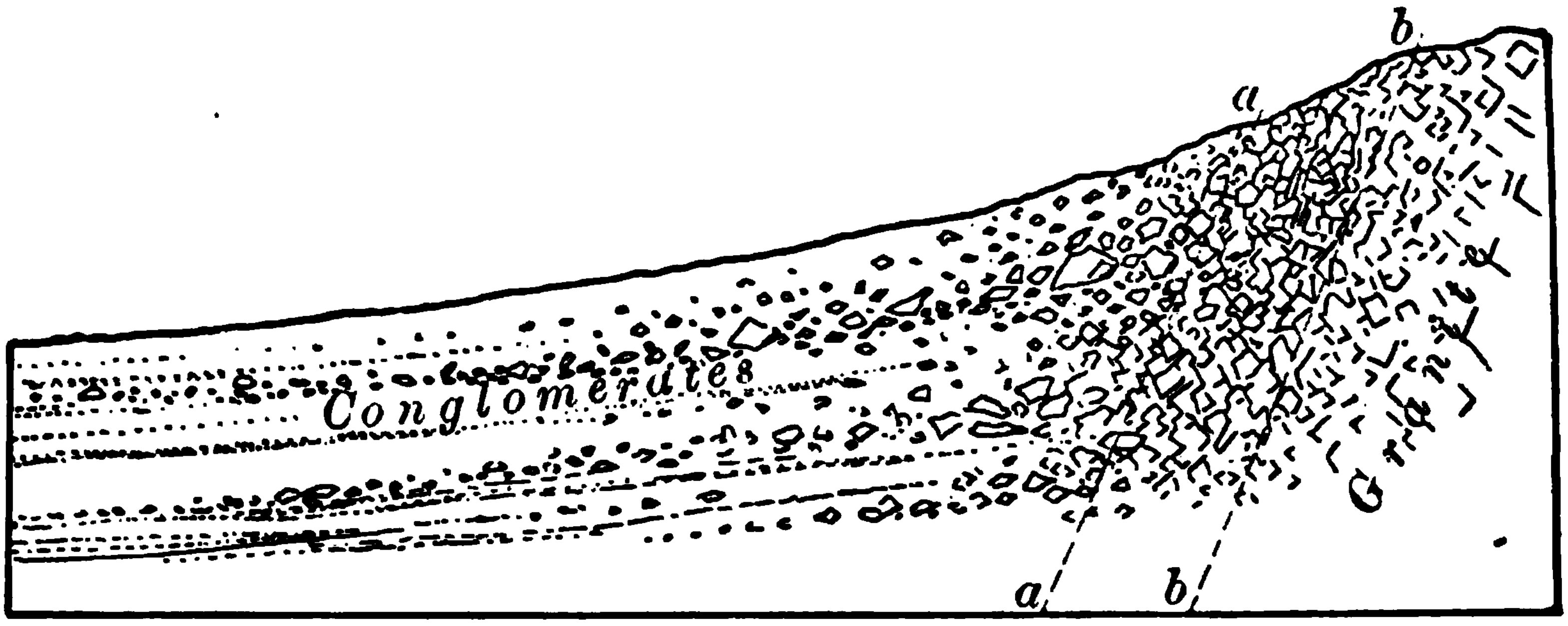
Plate IV.

Fig. 1.—Needle-Rock, Glen Eyrie, Red Triassic Sandstone.

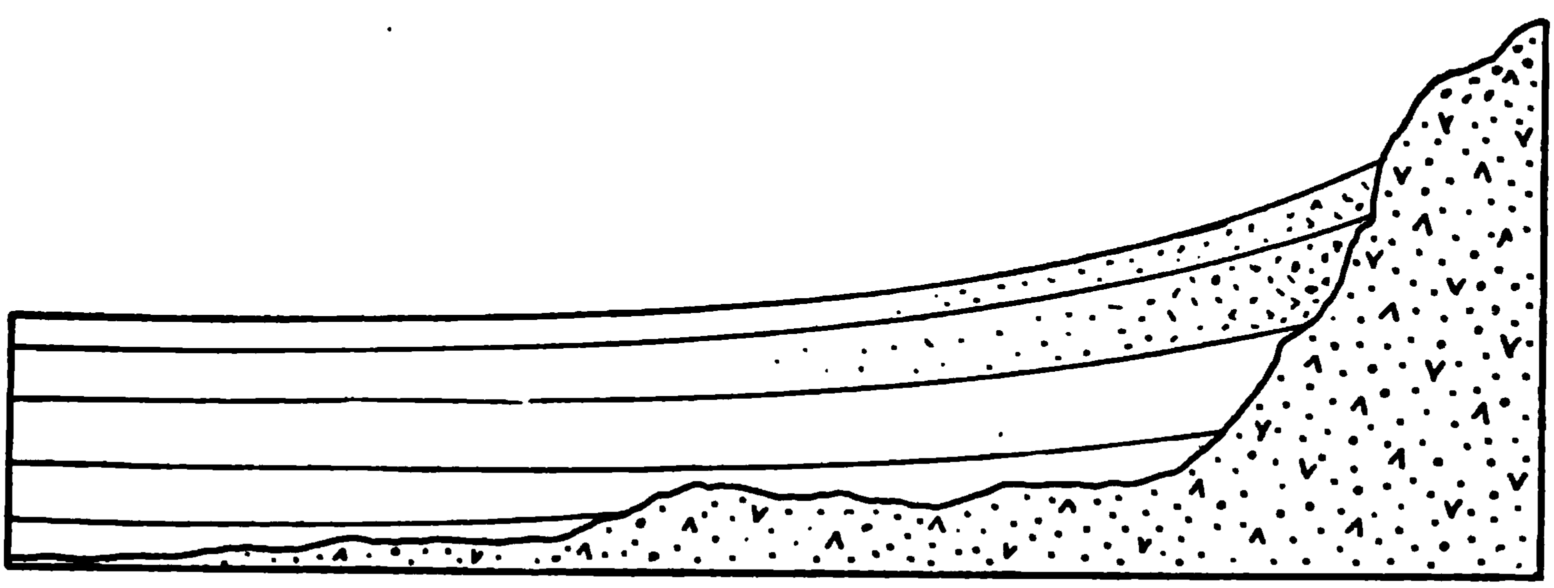
Fig. 2.—Concretions and Sandstones, Cretaceous Period.

FIG. 1.



Showing the changes in the sediments as we approach the granite "shore line." At the line a, the fragments are large and unworn. Farther out they are more rounded and have a matrix of pebbles and sand. Between the lines aa, and bb, there is a belt, that, although probably Sedimentary can hardly be distinguished from the true granite.

FIG. 2.



Thickening of Sedimentary beds along the "Shore line" as seen near Manitou.

Fig. 1.—Cross-bedding Lignitic Sandstones, near Colorado Springs.

Fig. 2.—Silurian Limestones resting Unconformably on Stratified Granite, Williams Cañon.

extent on both sides of the eastern ranges that front the plains, from the northern to the southern boundary of the United States, and how much farther I do not know. It is probable, however, that they extend far north into the British Provinces and far south into Mexico. This belt is very varied in its character from point to point, sometimes expands to a width of several miles, and again contracts to a fourth or half a mile in width. Sometimes a full series of the formations known in the west, from the older Silurian to the most modern Tertiary, are clearly exposed, inclining at various angles; and then again only the more modern beds can be seen. It is on this account that the geology, though appearing so very simple in its character, is really quite complex when examined in detail.

Up to this time we have determined the existence, in this belt in Colorado, of the Silurian, Carboniferous, Triassic, (?) Jurassic, Cretaceous, and Tertiary groups; yet, while the more modern formations are very persistent throughout the entire distance from the north to the south line, some of the older beds are wanting in many places. To the far north, along the margins of the Black Hills, Big Horn, and Wind River Mountains, the Potsdam sandstones, with perhaps more modern divisions of the Silurian, are well exposed and quite continuous, while to the southward these rocks disappear, except at restricted localities. We find near Colorado Springs and Cañon City quite large exposures of Silurian beds, with a few fossils that are allied to those of the Calciferous group of the Lower Silurian of New York. In the interval, from Fort Laramie to Colorado Springs, a distance of over 200 miles, no one connected with the survey under my charge has yet detected any trace of these beds. It is possible that in Pleasant Park, about 50 miles south of Denver, there are traces of this formation in the variegated sandstones that lie next to the granites, as shown in the section. At Colorado Springs, and in the vicinity, there is a considerable thickness of the Silurian beds, which have been frequently described. The reddish-brown, rather coarse sandstones at the base, rest upon stratified granitoid or gneissic rocks unconformably, as shown in the illustration (Pl. VI, Fig. 2). Above the sandstones there are 600 to 800 feet of yellowish limestone, which, in some instances, is a reddish color, in which have been found several species of invertebrate Silurian fossils. South of the valley of Fountain Creek the uplifted belt rapidly closes up to the base of the mountains, and for some distance no beds older than the Cretaceous are visible. From Fountain Creek to Cañon City this belt expands and contracts from time to time, so that it is quite possible that small isolated patches of the Silurian group may appear in a few places. At Cañon City, and resting for the most part on the mountain-sides, inclining at a high angle, there is an extensive thickness of these older beds again. The lower portion is a variegated micaceous, slightly calcareous, sandstone, closely resembling, in texture and composition, the Potsdam sandstone as seen in other localities farther to the north. Some tolerably well-defined fossils were discovered in the sandstone which rests directly on the granitic rocks, which Mr. Meek has pronounced of undoubted Lower Silurian age, but they have not yet been described. This sandstone passes up into a hard and rather massive limestone, evidently the same as that noted at Colorado Springs.

We cannot say more at present in regard to rocks of this age, than to state our belief that they underlie the entire country along the eastern slope of the Rocky Mountains, from our northern boundary to New Mexico, and that, where they are not visible, they may possibly be concealed by the overlying and more modern beds.

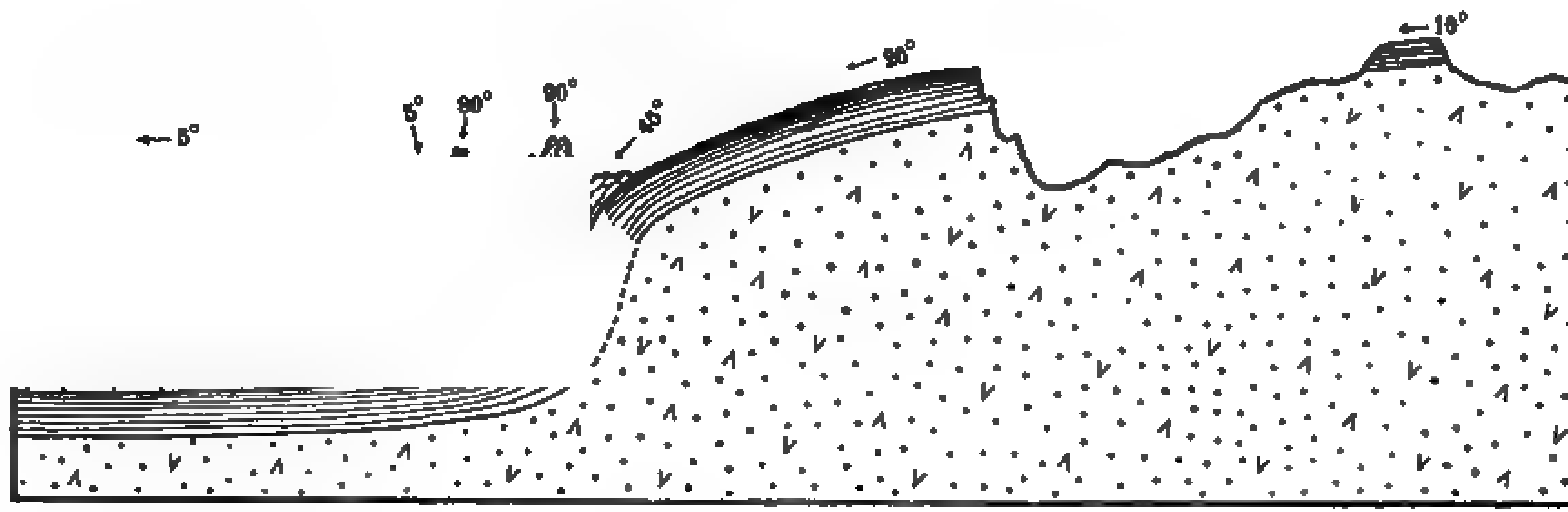
THE CARBONIFEROUS GROUP.

The Carboniferous group is a little more persistent, and yet this seems to be wanting over extended intervals, unless a portion of what have been called the Red Beds is of this age. This group is extensively exposed along the flanks of the mountains, 100 to 150 miles north of Cheyenne, as was shown in the annual report of 1870. It seems, however, to diminish somewhat in force, and to contain comparatively few fossils in its southern extension, until we reach Cañon City. From thence southward into New Mexico it increases again in thickness and importance, and yields an abundant supply of its characteristic fossils. I have no positive information of the discovery of any well-marked Carboniferous fossils from the line of the Union Pacific Railroad to the vicinity of Cañon City, although strata supposed to be of that age are exposed in a few localities. On the small map of "Colorado Springs and vicinity," a light band will be seen between the Silurian on the west and the Red Beds or Triassic on the east, which represents a peculiar group of strata not observed elsewhere on the eastern slope, but resembling very closely a series of variegated beds, described by Dr. Peale, in the annual report for 1873, in the valley of Eagle River, which yielded well-marked Carboniferous types. This group of strata is composed of variegated beds of sandstones of various textures, alternately with layers of arenaceous clay. The entire thickness was estimated at about 1,000 feet. It is most probable that these beds are of Carboniferous age.

From Colorado Springs the Carboniferous group is not conspicuous at any locality, and for a great portion of the way is not seen at all, but at Cañon City and Wet Mountain Valley the limestones and sandstones contain numerous fossils, both animal and vegetable. From the Wet Mountain Valley, which is but a short distance south of Cañon City, Mr. R. N. Clark collected specimens of vegetable remains from the Carboniferous beds, which were submitted to Professor Lesquereux. He detected *Stigmaria fucoides*, Brgt., showing scars of surface with stems and leaves attached; mold of the internal surface of the cylinder of a *Calamites;* small specimens of a new species of *Cordaites*, resembling by its nervation *Cordaites principalis*. An abundance of invertebrate fossils have been discovered in this group which have not yet been studied.

THE RED BEDS OR TRIASSIC GROUP.

The Red Beds or Triassic group is very persistent, and if absent at all, only at very short intervals. No organic remains have yet been found in this group by the members of the survey under my charge, yet, for various reasons, we have assumed the red sandstones to be of Triassic age. It is barely possible that a portion or all of the group is of Jurassic age. Yet Professor Cope is of the opinion that he has discovered evidence in New Mexico of its Triassic age. The history of this group is still obscure, and remains as one of the problems to be solved by more extended and more thorough explorations. Geographically, it is one of the most widely distributed formations in the West. From the northern boundary to the southern line and east of the Wasatch range in Utah, this red formation makes its appearance wherever a mountain-range is elevated so as to expose the various sedimentary groups. The evidence indicates that it extends without any important interruption over the broad area as defined above. This group is generally admitted to be in part, or entirely, of Triassic age, and I have always so regarded

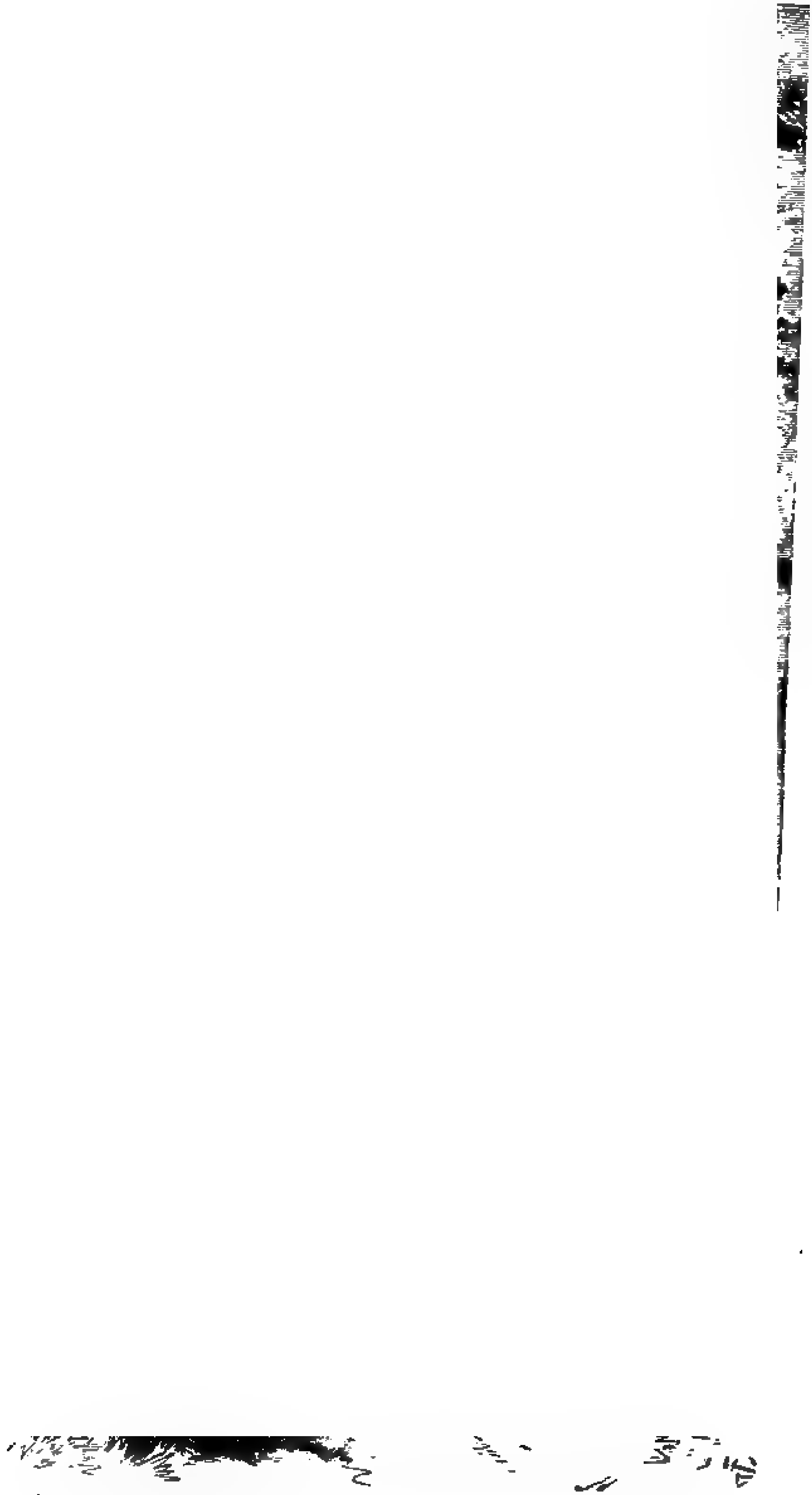


IDEAL SECTION, *showing the manner in which the great diversity of surface dip is probably produced.*

SURFACE SECTION *near Glen Eyrie Col*

Plate VIII.

Plate IX.



Cathedral Rock, "Garden of the Gods," Colorado, Red Triassic Sandstones.

it, since my first examination of it, nearly twenty years ago, yet more direct proof must be brought to bear before long in some portion of our continent. These red sandstones have always attracted much attention wherever noticed, on account of their peculiar color, but nowhere have I ever observed them performing such a conspicuous part in giving form to the scenery of the country, as along the eastern base of the Rocky Mountains in Colorado. This feature is more marked from a point about fifty miles north of Denver to Colorado Springs, than in any other portion of the continent. Along this belt the sandstones are more compact, with every variety of red, from a pale dull tint to a deep purple color. There is also every variety of texture, from a rather coarse conglomerate to a fine sandstone. It varies much in thickness, ranging from 400 to 2,000 feet. Its greatest thickness south of Platte Cañon is in Pleasant Park and in the "Garden of the Gods," at Manitou. At Pleasant Park, according to Dr. Peale, the aggregate thickness of the Red Beds is about 2,000 feet. This series of beds is well shown in the pictorial section. These sandstones have been elevated at various angles varying from 20° to a vertical position. In the vicinity of the Manitou Springs, in what is usually called the "Garden of the Gods," the same variation is seen, but in many instances the beds are very massive, thick, and stand in a nearly vertical position. In Plates VIII and IX we can see the massive sandstones, which have been weathered into the most fantastic shapes, standing up in immense walls or columns 50 to 250 feet in height. Plate VIII represents what is called the gate or entrance to the "Garden of the Gods." In the foreground is seen the massive wall of red sandstone rising on either side of the opening to the height of 100 to 150 feet. The wall was originally continuous, but has been worn through by erosion. Whatever may have been the agents which in times past have wrought out all these remarkable forms, it is plain that they have acted in former times with far more intensity than at present. In the background, through the opening, may be seen the snow-capped summits of Pike's Peak, rising to a height of 14,147 feet above sea-level. Plate IX gives an example of what might be called a magnificent monolith. It is an immense column of bright-red Triassic (?) sandstone rising to a height of 250 feet above the general level, a portion of a massive stratum elevated to a vertical position, and the contiguous portions eroded away. Figure 1, plate IX, illustrates the singular columns which stand at the entrance of the "Little Garden of the Gods," or, as it is now called, "Glen Eyerie." On account of the peculiar forms which these red sandstones have received from the eroding agents of nature, this locality will always remain one of the most celebrated in Colorado.

The more careful study of the relations of these sandstones to the underlying rocks, has thrown much light on the physical history of this region. My own observations, farther to the northward, led me to the belief that the great uplift of the mountain-ranges, though imperceptibly slow, was an unit in its action; or, in other words, that the changes in the position of all the groups were brought about by the same cause and at the same time. There could not be a strict conformity in the sedimentary groups, inasmuch as entire groups are wanting, and in some cases only fragments of others are remaining. But I have hitherto supposed that the elevation of all the sedimentary strata along the base of the mountains was a comparatively modern event. We now have the evidence, from the texture of these red beds and their position on the underlying granitic rocks, that the Front Range, during the supposed Triassic period, formed a vast shore-line, and that the sediments of the Red Beds were deposited on the base against the sides of

the granitic range. In the annual report for 1873 the fact was that the Red Beds, in the form of coarse conglomerates, filled uneven surface of the granitic rocks below. South of Mani find an enormous thickness of very coarse conglomerates, cement rather fine sands, jutting up against the mountain-sides, showing that, although elevated and disturbed to a certain extent sinc deposition, they were laid down along the base of the Front Ran shore-line, and that there must have been a period of compara pose. When these sandstones, near the base of the mountains, ar to be made up of conglomerates, they are observed to be very in the immediate vicinity of the granites, but becoming finer an sandstones as they extend eastward into the plains. There shoul fore be some nonconformity between the Triassic and the Carbo and Silurian groups below, for both of the latter extend high up flanks of the mountains on either side, sometimes occurring on th mits of the lower ranges. The section in Plate VII would indicat thing of this sort, for we find the Silurian and Carboniferous in 20° and 45°, while the Triassic dips 90°, or is very near a vertical diagram also shows how the Silurian beds lie high up on the flanks of the mountains. The elevatory force seems to have act tically, bending the overlying sedimentary strata like metallic sh that within a few yards of the nearly vertical beds the same ar zontal or nearly so. This will explain very clearly the abruptnes which the mountains seem to rise out of the plains to the trave proaching them from the east.

The beautiful pictorial section of Pleasant Park may need a w explanation here. The dotted line *a a* shows that all the elevate tion in the rear or west of it is composed of granitic rocks. The line in the foreground, *h h*, shows the junction of the Lignitic to the true Cretaceous beds which here rise up in a very narro from beneath the Monument Creek group. It is exposed by the ing away of the Monument Creek beds. The letter *i* indicat usual form and isolated character of the numerous buttes that ar tered over the plains here for a considerable distance east of the m ains. The strata are nearly horizontal, the summits are flat, shaped, and are not unfrequently capped with trachyte. Betwee dotted lines the Carboniferous, Red Beds (Triassic), Jurassic, and taceous groups are exposed. The manner of inclination and the tion of these groups to the granitic range, as well as to each oth made clear by the section.

THE JURASSIC.

This formation has already been described in so much detail in vious reports, that I shall mention it very briefly in this conne Far to the north this group holds a prominent position, not only o count of its aggregate thickness, but also from the abundance variety of its organic remains. South of the Union Pacific Railroa Colorado, it is confined to a very narrow belt, with very few if any sils to establish its age. That it extends most persistently far so ward into New Mexico, there cannot be a doubt. The narrow belt w it occupies is well shown in the small map of Colorado Springs and cinity. North of the Pacific Railroad, along the base of the front ra of mountains, it increases in thickness and is full of characteristic sils. In the annual report for 1873 and previous reports, the lithol cal characters of all of these groups have been so fully discussed th

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would be mere repetition to refer to them in this report. The Jurassic group in Colorado has little or no influence economically or in giving form to the peculiar scenery.

THE CRETACEOUS.

The Dakota group is composed of massive beds of sandstones intersected with layers of clay, and forms some of the most conspicuous ridges or "hogbacks" along the eastern base of the Front or Colorado range. Its importance, however, varies in different localities as much as its texture; sometimes it is scarcely seen and then again it forms one or more of the most important ridges. Its aggregate thickness is never great, varying from 200 to 400 feet, and may be represented by a very narrow belt on the map. West of the 100th meridian it has yielded very few organic remains, although it has a very extended geographical range. It is hardly ever wanting along the margins of the mountain ranges east of the Wasatch Mountains, in Utah. From its structure in the far West, I regard it as a sort of transitional group between the well-defined Cretaceous group and the Jurassic below.

Numbers 2, 3 and 4, or the Fort Benton, Niobrara, and Fort Pierre divisions, may be regarded as one group, under the name of the Colorado group, as adopted on Clarence King's beautiful geological map of the Green River basin. To one who has never studied these divisions in the Northwest, along the Upper Missouri River, there would seem to be no occasion for their separation. Having studied these divisions with much care in their typical localities, along the Missouri River and in Eastern Kansas and Nebraska, I found very little difficulty in tracing them across the country westward and southward, so far as my explorations have extended. It is very doubtful, however, if any geologist would have ever separated the Cretaceous beds between the Dakota and Fox Hills groups into divisions, had they been first studied in the interior of the continent. The Fox Hills group has a very important influence on the physical history of a most important geological period. It was at the close of this period that one of the most important biological changes occurred in geological history. So far as we know at the present time, no animal-remains, and very few, if any, vegetable forms, passed above it. A few species of plants probably began their existence in the Upper Cretaceous in the Fox Hills group and continued on up into the Lignitic group, where they reached their highest point of development. The gradual approach of shallow seas is finely shown in the character of the sediments in the upper portion of the Fox Hills group. Not only the shallow seas but the gradual change of salt to brackish and then to purely fresh waters was amply sufficient to destroy all traces of marine life, which occur so abundantly in the Fox Hills group. Fig. 2, Plate IV, presents a fine illustration of the remarkable concretionary masses which characterize in many localities the upper portion of the Fox Hills group as it passes into the brackish-water strata of the Lignitic or Laramie group above. This cut, though intended to illustrate a portion of the Dakota group in Eastern Kansas, serves perfectly to explain to the eye the immense rusty-brown concretions which abound in the mud-beds just beneath the lower sandstones of the Lignitic group at Cañon City and at Colorado Springs, and at other localities in Eastern Colorado. These concretions are peculiar rounded, regularly stratified masses, often merely resting upon the pedestals of the softer and more regularly bedded sandstones below. So far as Colorado is con-

cerned, I have observed no locality where there appeared to be any striking nonconformity between the Fox Hills group and the Lignitic group above. That there may have been intervals of time, during which the Cretaceous sediments were not deposited; that there may have been dry land over large areas, is not impossible, but there could have been no great degree of erosion of the surface of the upper Cretaceous beds. This apparent conformity, while in certain localities the upper Cretaceous beds received a very much increased thickness, may be due to a far more rapid deposition. In almost all cases, the transition from the Fox Hills group to the brackish-water deposits of the Lignitic seems to have been gradual, with no visible physical break of importance. The great break seems to be illustrated only in the entire change in the animal and vegetable life.

But the time at my disposal will not permit me to discuss here many important questions in this connection. For the details of the geology of the Eastern base of the mountains in Colorado, the reader is referred to the previous annual reports of the survey, especially the one for 1873.

Plate X.

Foliation of Granite in Estes Park, Colorado.

Plate XI.

CHAPTER IV.

ANCIENT LAKE BASINS.—GLACIAL LAKES.—MORAINAL DEPOSITS IN THE VALLEY OF THE UPPER ARKANSAS RIVER AND ALONG BOTH FLANKS OF THE SAWATCH MOUNTAINS.

For nearly twenty years I have written more or less in regard to the ancient lake-basins of the West, but it was only within a few years, since the facilities for traveling have so greatly increased that geologists have found that these lake-basins once occupied the entire country from the Arctic Circle to the Isthmus of Darien. In very many instances they were merely expansions of river valleys, like the greater number of our lake-basins of the present day. During the early portion of the Tertiary period, the western portion of our continent was covered with immense lakes, some of which occupied a much larger area than any we are acquainted with at the present time. During the Pliocene period, and during the interval to the present time, thousands of small lakes, with a few of large size, were distributed over the great area west of the Mississippi, and the basins with their peculiar deposits are found in the parks, among the mountains, and along every important river-valley. The gathering together of the vast amount of information which is now accumulating on this subject is a task which will, at no distant day, be productive of most interesting results.

I have made these few remarks to introduce what I may have to say in regard to the valley of the Upper Arkansas River.

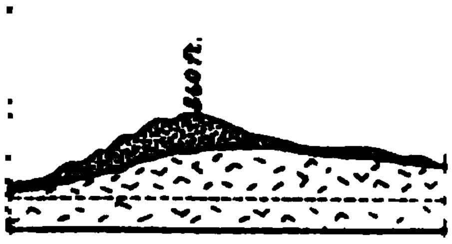
The Arkansas River rises in the Tennessee Pass, nearly west of Mount Lincoln, in latitude 39° 21′ and longitude 106° 19′, and flows a little east of south for a distance of about 80 miles in a straight line, when it flexes to the east, and flows through a deep cañon in the granite, and emerges into the plains near Cañon City. Near the sources of the river are several expansions of the valley from one to two miles in width, oval-shaped, and covered with a deposit of drift-material. Near the junction of the east branch of the Arkansas the valley, with the terraces on either side, continues pretty regularly about five to eight miles in width, but gradually closes up again below Lake Creek, though on either side are vast deposits of the coarse drift-material extending high up on the mountain-sides, especially on the west side of the valley. The valley then gradually expands out and enlarges about five to ten miles in width for a distance of nearly 40 miles. In the annual report for 1873 I have expressed my belief that this valley began in a monoclinal interval, with the great Sawatch range on the west side forming the crest of the continental water-shed, and the Park range on the east, which, with its sedimentary rocks and granite basis, formed the east side of a grand anticlinal, the aggregate mass of rocks inclining to the eastward. Our observations over a very extended area only confirmed the opinion expressed in our last report, that the great Sawatch range formed the central portion of a gigantic anticlinal. The west side of the Park range is, for the most part, very abrupt, and for long distances the gneissic rocks show very clearly the direction of the dip. On the east side the sedimentary rocks dip down under the surface of the South

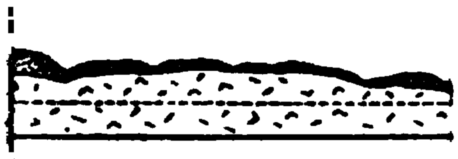
Park. On the west side of the Sawatch range we have the valley of the Gunnison, and west of that the sedimentary rocks incline to the westward, unless disturbed by some center force, for the Elk Mountains.

On either side of the valley small streams flow into the main channel of the Arkansas from the source to Cañon City. These streams usually have their origin at the very crest or water-divide of the two ranges, and in most instances have cut their way through the solid mass to the main river. Many of these streams have numerous side-branches which have also carved out wonderful gorges near the crest of the mountains, giving to these mountain ranges a ruggedness that is almost inconceivable to one who has not actually explored them. It is in the study of these gorges that the geologist learns to appreciate the immense results of erosion in giving form to the rocky range of the West. Even yet the power of this force has not been adequately understood, but the wider our range of observation, the greater is our conception of its power. We may safely assert that at some period comparatively modern, 10,000 or 15,000 feet of sedimentary beds extended uninterruptedly from the South Park across the interval now occupied by the Sawatch range, all of which, but insignificant remnants, have been swept away, while a mass of the granite nucleus, of inconceivable dimensions, has also been removed. The general elevation of the Sawatch range for 60 to 80 miles is 13,000 to 14,000 feet above the sea at this time, and it is highly probable that hundreds and perhaps thousands of feet have been removed from the summit. I find it difficult to estimate the extent of the erosion in this region, and can only speak of it in general terms as almost inconceivable to a finite mind.

From the nature of the interval or valley, the greater number of streams flow into the Arkansas from the main Sawatch range. They are quite numerous from the Tennessee Pass to Cañon City; a few come in from the east side, but the drainage tends toward the east or southeast, so that the streams that rise in the Park range and flow into the Arkansas are comparatively few and of little importance. The character of this drainage is well shown on the map accompanying this report.

In the last annual report I dwelt with considerable detail on the effects of glacial action in this valley, and, in this report, I can only describe them in general terms, hoping that the beautiful maps and illustrated sketches by Mr. Holmes will render the story plain to the reader. As an illustration of the effects of glacial action in this valley, Lake Creek might be taken as an example. This stream rises in several branches at the very crest of the divide, forming vast amphitheaters. The signs of past glacial action are not very evident about the sources of their side-branches, and they do not reach higher than 12,000 or 12,500 feet. The summits of the high mountains are often covered with *debris* of broken rocks, apparently not much worn. In some places the tops of the mountains, like Mount Lincoln for example, are, with the exception of the extreme summit, covered with a thick covering of earth, filled with rocks more or less worn. The most conspicuous signs of glacial action are seen along the sides of the gorges lower down the streams. In the valley of Lake Creek, the sides of the gorge are worn smoothly for an elevation of at least 12,000 feet or above timber-line, and from 1,000 to 1,500 feet above the bed of the creek. In many places the sides of the gorge or cañon are worn so smooth that the surface has the appearance of enamel, and a thin crust usually peels off, which I have hitherto denominated a "glacial crust." About four miles above the Upper Twin Lake on the north side of the cañon there is a round mass of granite projecting from the side 300 feet or more, and 1,000 feet high, with





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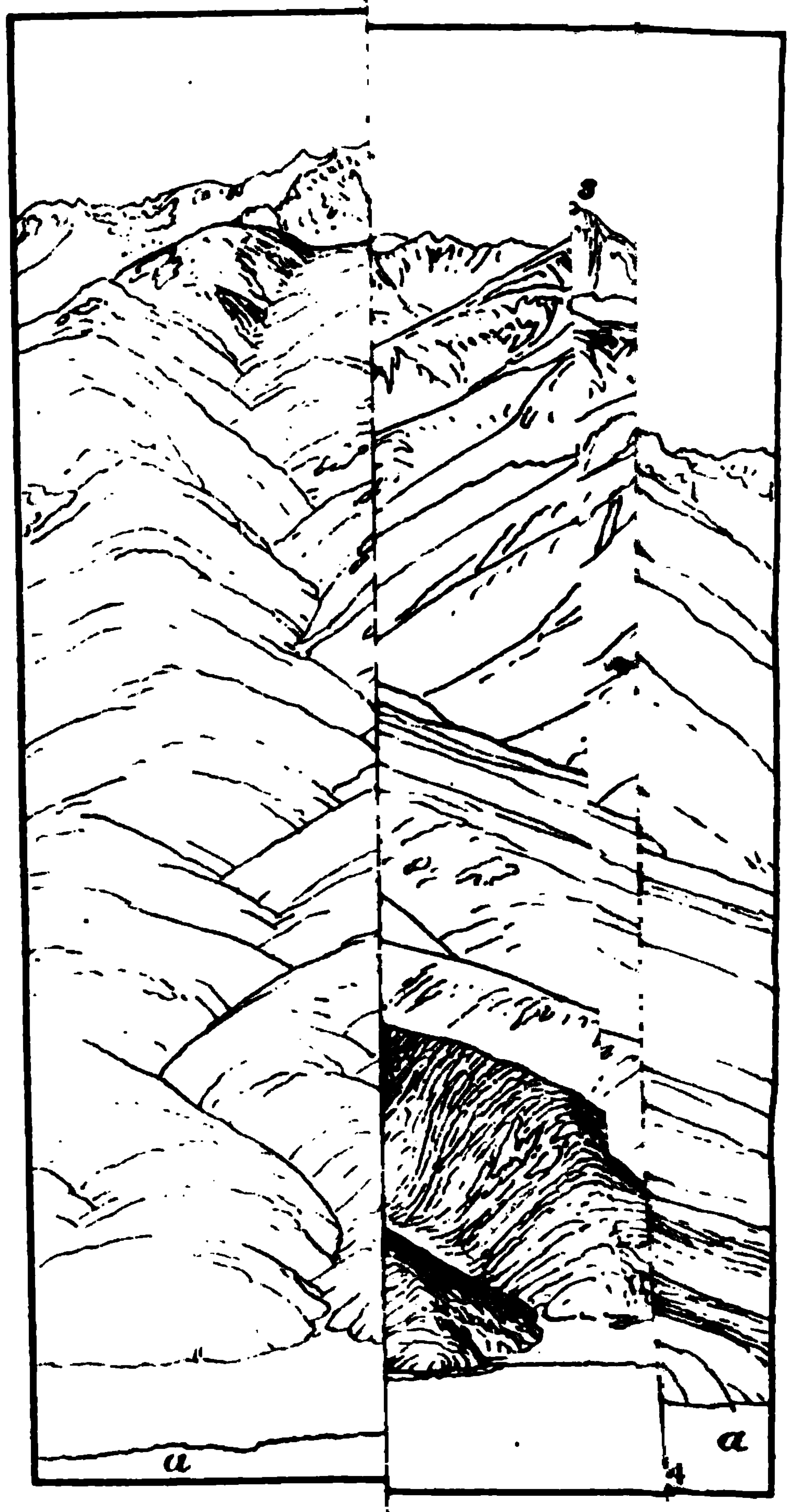

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somewhat the appearance of a bastion which has been worn quite smooth. In the sides of it are depressions like pot-holes, evidently worn out by the attrition of loose rocks against the sides as the water flowed underneath the glacier. There are also points where vast masses of granite have been removed from the sides of the mountain at a great height, giving to the mountain-side the appearance of an ancient quarry.

For a distance of about eight miles the bottom of the valley will average one-fourth of a mile in width, with here and there huge masses of granite projecting above the general level, showing very clearly that the entire valley has been carved out of the solid granitic mass. The loose morainal deposits are not conspicuous until we reach a point about two miles above the Upper Twin Lake, where the valley expands out to about a mile to one and a half miles in width. Here a low swampy bottom commences, which was once, undoubtedly, a portion of the lake. On either side are ridges of the glacial deposits; these increase in size and importance as we descend to the junction of the creek with the Arkansas. On the south side of the lower lake a ridge extends from the mountains down to the Arkansas River, perhaps 1,000 feet high, just south of the upper end of the lake, and gradually sloping down 100 or 150 feet in height above the bed of the river. This is a true morainal ridge, and was doubtless formed by the crowding out on either side of the loose materials as the great glacial mass moved down the valley of Lake Creek. This morainal deposit undoubtedly laps on to the mountain-side so that the nucleus of the upper portion of the ridges is granitic. The drift deposits are not generally more than 500 to 800 feet in thickness, and usually much less. The granite crops out in numerous places on the sides of the ridge, showing most clearly that the greater portion of its nucleus is granitic; it also shows that the valley, with the surrounding terraced hills, has been worn down by erosion from an elevation as great perhaps as the loftiest portion of the main range. The north side of Lake Creek is a very irregular ridge, full of depressions, while on the west side of these ridges are extensive accumulations of rocks more or less worn, showing the direction of the moving force. Besides the vast lateral moraines in the valleys of the streams, there are a great number of what may be called terminal moraines, or detached ridges that tend in various directions. Sometimes they extend a portion of the distance across the valley at right angles to the lateral moraines, or they may diverge at any angle; the great quantities of loose material attached to the glacier seems to have been dropped in quite irregular forms as it moved down the valley. In one instance the granite crops out at the east end of the Lower Twin Lake, about the middle of the valley, and under such circumstances that the inference is plain that the entire valley has been worn out of the solid mass of granite. One of the main objects of our description of the morainal deposits is to show the extent of the erosion which has taken place in this region, and these outcroppings of granite are the remnants that are left as proofs of the magnitude of this work. From Mr. Derry's house, on the northwest corner of Lower Twin Lake, we have perhaps as good a general view of this valley and its surroundings as we can find. As we look to the south of west we see two front peaks, which are shaped like cones, rising up to the height of 12,500 to 15,000 feet. A little to the southeast is an unnamed cone, with a broader summit, rising above timber-line. Although these points or peaks appear to be independent, yet they are really portions of spurs or ridges extending down from the main peak, which extends further to the west and forms a part of the crest of the range, to which we

have given the name of La Plata, 14,302 feet above the sea. As we look in this direction, bare, brown, granite masses, rising above timber-line, meet our eyes, with here and there a few patches of snow to break the monotony or contrast with the desolate somber hue of the granite *debris*. Deep furrows extend down the sides of the mountains, the channels for untold ages of ice, snow, and water, the agents which have broken down these rocky masses and sculptured the forms which now so much excite our admiration. We see also the smoothly-worn sides of the mountain covered with a sort of enamel-like crust, as a mark of the glacial power. On the sides of the peaks, at different elevations, are numerous small green lakes, sometimes with a visible outlet and sometimes without, reservoirs of the melting snows. The pines are often dead from the autumnal fires that have run through, adding to the desolation of the scene; these falling down in every direction render traveling almost impossible. Sometimes no vegetation takes the place of the pines after the fires have passed through them, but not unfrequently the quaking-asp poplar, with its bright green leaves in summer and yellow in autumn, grow very densely, contrasting most charmingly with the somber green of the living pines, and the somber brown or gray of the dead. Down in the valley, and closed in on either side by mountains and the morainal ridges or hills, are the two beautiful lakes, which are laid down on maps as Twin Lakes, the basins of which were no doubt formed by glacial action. If the reader will examine the map accompanying the report he will see more clearly than we can describe in words the location of the beautiful lakes, the morainal ridges and mountains that hem them in; the contour lines are not intended to indicate elevation, but are used to show the surface forms. As there are really but two forms, granite and morainal drift, but one color is needed, and with this we have endeavored to separate the surface covered with the morainal deposit from the granite. The map will also show the elevation of the lakes above the sea, 9,182 feet; also the elevation at the junction of the Lake Fork and the Arkansas, 9,096 feet. The depths of the lakes are shown by actual soundings. The greatest depth of the upper lake is 79 feet, and that of the lower 75 feet. It will be seen that the greatest depth of the lower lake is near the upper end. We may thus see by the depth of these lake-basins, as well as their shape and morainal deposits around them, that the force that produced them all moved slowly down from the mountain-range, and that the lake-basins are scooped out of the solid granite rocks. From the lower lake to the Arkansas River the morainal deposits are very thick; the surface is covered with bowlders more or less, and of greater or less size, some small, others from 20 to 50 feet in diameter. Hundreds of mounds, ridges, and curious depressions, of all shapes and sizes, impede the traveler. The placer-mining has been very extensive here, and by this means we arrive at the true character of this glacial drift. It is composed mostly of rounded bowlders, but mingled with it is a kind of light-colored clay and sand. The decomposition of the feldspar has produced a kind of clay, which sometimes gathers into localities forming a considerable thickness.

The description of the glacial action in the valley of this branch of the Arkansas will apply to the others, and presents a general view of the detailed action in the entire valley. The history of this valley from the beginning may be in some points obscure, but, as I have stated in a former report, I regard it as largely due to erosion. In the process of elevation a fissure or fissures must have been formed, and in these the process of erosion commenced, continuing through a vast period of time

and operating with greater or less effect at different portions of that period. So far as the drift-deposits are concerned, which at the present time seem to be the only material resting on the granite in the valley, they are undoubtedly of comparatively modern origin, not extending back farther than the Pliocene, but the beginning of the erosion may reach into the past as far as the Jurassic. We have now the evidence that indicates that portions of these mountain-ranges were elevated above the Jurassic seas, and we may suppose that the general outline of the surface continues on the same plan up to the present time. If this was true—and we have no reason to believe the contrary—the erosion may have, and probably did commence far back in the past, and that during the Cretaceous and Tertiary periods the area occupied by the Sawatch range was elevated above the waters; it is more probable, however, that these formations were deposited to a greater or less extent over this area, and that they have been entirely removed or ground up with the present drift. From the source of the Arkansas at the Tennessee Pass to the cañon above Cañon City, the distance is about 60 miles, supposing this to be mainly a valley of erosion, area worn away would average about eight miles in width, the depth could not have been less than one mile, so that an approximate estimate can be made of the enormous amount of rock-material has been ground up in the excavation of this valley. Up to the time of the great glacial period this eroded material may have been swept out on to the plains to assist in forming the vast Cretaceous and Tertiary beds which we find there at the present day. Geologists generally admit that about the close of the Tertiary period, there was an era of intense cold, which they have agreed to call the glacial epoch, and our remarks are based on that supposition. We believe that at one period this entire valley, with all the side-valleys or cañons, was occupied with one vast glacier, diminishing and increasing as the temperature was higher or lower, but gradually moving down; that is, the main mass moving southward, and the side-branches moving toward the central mass. As the sides of the mountains are worn smoothly and exhibit signs of glacial action to the height of at least 1,500 feet above the valley, we may arrive at an approximate estimate of the thickness of the glacier. The fissures of the Arkansas and its branches may not have been nearly as large at the commencement of the glacial period as at the present time, and the great glacier may have performed the work of erosion for ages, and gradually melting by a change of temperature to the mild climate of the present time, left the numerous mounds, ridges, and other morainal deposits which we find so extensive in this valley, and in many other portions of the Rocky Mountain region. I have spoken of this great ice-mass as a single glacier; there may have been a single one increasing and diminishing through ages with the changes of temperature at different seasons or epochs, or there may have been an unlimited number of glaciers, but the glacial phenomena as indicated by the present surface of that country shows a long and continuous period of action. I have before stated that I regarded the valley as one great lake-basin, commencing near the Tennessee Pass. The valley expands out somewhat for the first ten miles, and gradually closes up below the town of Granite for about four miles, when it opens out again into a broad, level, basin-like form. The bottoms of the main river, as well as the little branches, expose the granite rocks in such a way that we cannot well avoid the conclusion that they have been worn down to their present position from an elevation not much inferior to the Sawatch or Park ranges.

Above the Lake Creek on both sides of the Arkansas are well de-

fined terraces, which on the east side rise 600 feet above the river. The coarser materials were evidently deposited in water, and are arranged in strata and appear not to have been disturbed to any great extent by changes of level. On the west side the terraces slope down more gradually, and are cut from west to east by deep gorges, by streams from the main range. The valley itself extending to an elevation of 400 to 600 feet on either side, is filled up with more or less coarse drift-deposits. These vary much at different points, sometimes made up of huge bowlders, inclosed in loose gravel, sand, or clay, and again a rather fine deposit of sand, gravel, or clay, to all appearances having been deposited in comparatively quiet waters. At any rate there were at all times portions of the lake that were not subject to great currents or any violent agitation. On the whole, however, the drift-materials are very loose, showing that the movements of the water and ice were from north to the southward. All over the surface are scattered in vast quantities immense bowlders of granite, varying from a few feet to 50 feet in diameter. Below Granite, for four or five miles, the masses of granite are remarkable for their number and size, which appear to have been moved down Clear and Pine Creeks. Along the sides of Clear and Pine Creeks are high ridges, or lateral moraines, which may properly be compared to huge railway embankments, rising to a height of 400 to 800 feet above the valleys of the streams. Below the mouth of Pine Creek the valley soon expands, and the surface is covered with loose bowlders, while the ridges and depressions are quite remarkable, and give it almost an artificial appearance. These basin-like depressions inclosed by the moraines are not unfrequently filled with water, forming small lakes, often with no visible outlet. These little basins of water occupy different elevations, from the bottom terrace near the river to the point of junction of the drift on the mountain-sides, 800 to 1,200 feet above the river-bed. As we descend the river the bowlders diminish in size, are more rounded, and the deposits of fine materials increase in thickness. Below the mouth of Chalk Creek the valley is covered with a series of yellow-white marly beds, which are cut up into a variety of singular forms, resembling the "Bad Lands" and reaching an aggregate thickness of 800 to 1,200 feet. These were observed by me in 1869 and named the "Arkansas marls." Overlying these marls there is considerable thickness of coarse drift which forms to a great extent the terraces which are very marked for a distance of 30 miles. We can see, therefore, that the greater part of the finer sediments were transported to the lower or south end of the river-lake, and deposited in comparatively quiet waters. While we ascend the Arkansas Valley toward the Tennessee Pass, the proofs of great force from the combined action of water and ice are shown on a grand scale. It seems, too, that while there is a variety of deposits in this valley resting upon the granites, their history is consecutive and attributable to one general cause, local glacial action, so far as I have yet observed. I repeat the same statement which I made years ago, that I have observed no proof of any wide extended drift-action like that of the New England States, but in the Rocky Mountains the superficial deposits are all of local origin; and the source is usually limited to the drainage of the streams in which it is found. For example, although, as I have stated, I believe that all the marls and coarser deposits in the valley of the Upper Arkansas have the same origin, however different in composition, the forces that produced them are limited geographically to the drainage of the Upper Arkansas. I could find no indications that any fragment of rock had been transported even from so short a distance as beyond the drainage west of the Sa-

Plate XIII.

watch or east of the Park ranges. It is possible that a more detailed study of the superficial deposits of this valley would afford reason for a separation into different periods so that they might be classified, but my observations lead me to place them in one great period extending from the close of the Pliocene up to the present time. As is shown by the map, the drift-deposits rest upon the granite directly, and no sedimentary beds of any other age are found in the immediate valley, and these deposits in the aggregate do not afford proof of any break in time. Still much new matter could be added to the history of their deposition if an entire season could be devoted to their study.

CHAPTER V.

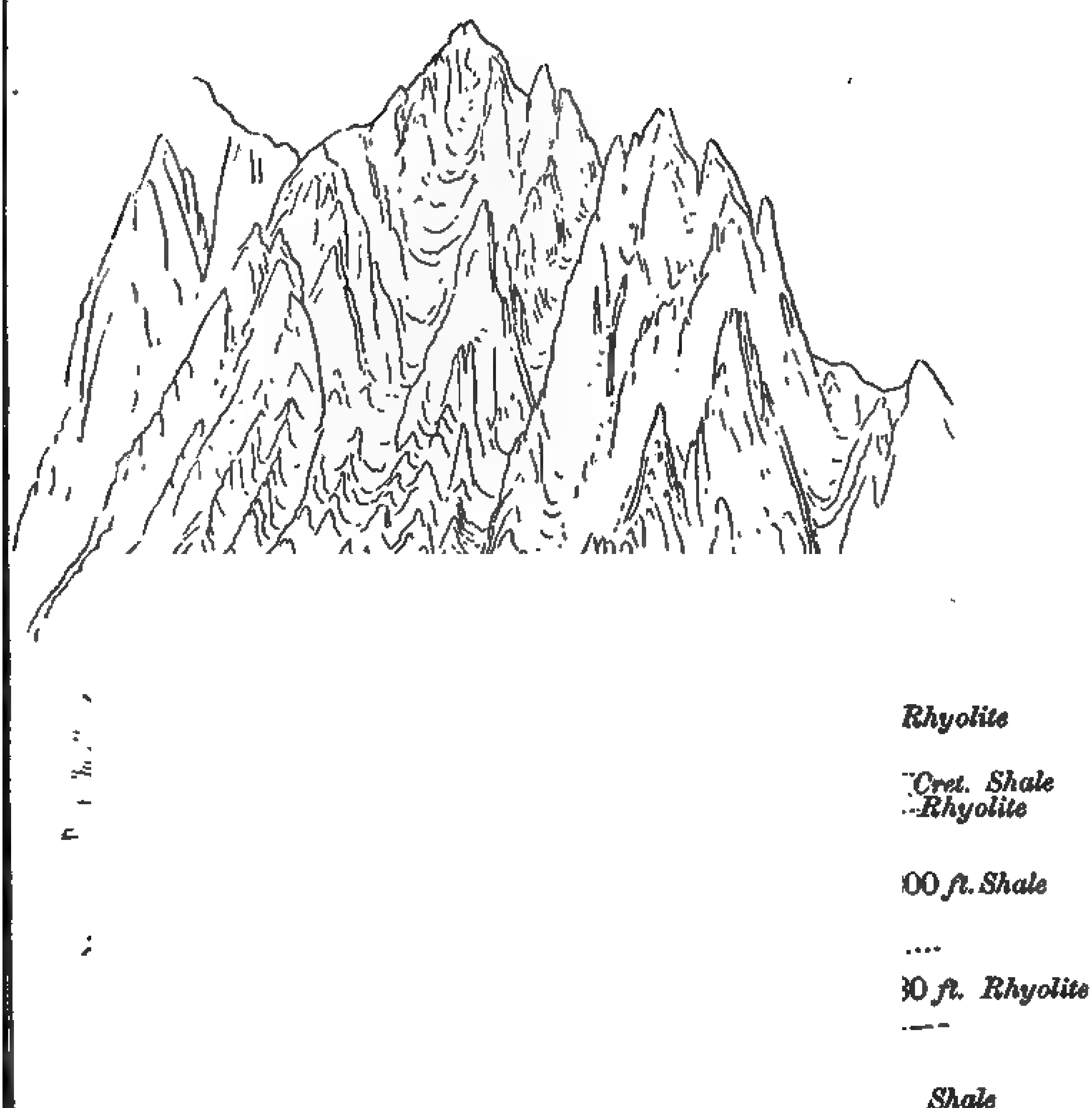
GENERAL VIEW OF THE GEOGRAPHY AND GEOLOGY OF THE ELK MOUNTAINS.—ERUPTIVE GRANITES.—RHYOLITES AND DYKES.—EROSION ON A GRAND SCALE.—LOCAL DRIFT-DEPOSITS.

The Elk-Mountain group is one of the most remarkable ranges in our western Territories, and, so far as my own explorations have extended, is unique in form and structure. For this reason a small party was organized in the summer of 1874 under my immediate direction, with Mr. Holmes as assistant geologist, and Mr. Chittenden as topographer, for the special study of this curious and most interesting group. The numerous sections and maps which are given in this report form a portion of the results of this specific study. Much attention was given to this region the previous year, and the results printed in the annual report for 1873. As our explorations are extended to the westward of this range, we hope to be able to present a more complete geological as well as topographical view of this region.

The Elk-Mountain group lies immediately west of the great Sawatch range, which forms the water-divide of the continent. It occupies an area of about 800 square miles, between meridians 106° 45′ and 107° 15′, and parallels 39° 30′ and 39°.

The Sawatch group is one of the loftiest and most symmetrical ranges in the West. It extends from the Mountain of the Holy Cross to the north, latitude 39° 28′, longitude 106° 28′, southward to the San Luis Valley, a distance of over 80 miles. For this entire distance the range literally bristles with lofty points, about ten of which rise above 14,000 feet, and many more are 13,000 feet above sea-level. The uniformity of this great mountain-mass is a remarkable feature. Standing on some high peak and glancing along its pointed summits from north to south there seems to be comparatively little variation either in form or height. On either side of the Sawatch range there are several somewhat lower parallel ranges which are undoubtedly portions of an immense anticlinal, of which the main granitic mass is the central nucleus. Between each of the parallel portions of the anticlinal are valleys at intervals of greater or less width. Immediately west of the granitic nucleus is the valley of the Gunnison, and on the east, the valley of the Upper Arkansas, and east and west of them are comparatively low granitic ranges capped with sedimentary rocks. Both the metamorphic and sedimentary rocks incline at various angles from the great central mass.

There are here represented two quite distinct types of mountain elevation, though the forces have influenced each other's results to a greater or less degree. The Sawatch or main range presents an example of a long-continued, uniform movement upward, which, but for the intervention of side-forces, would have produced a remarkably symmetrical mountain-group with the main granitic core or central mass, and on either side parallel valleys and ranges, each becoming lower and lower until the ridges faded out in the plains. The sedimentary rocks would have inclined at various angles east and west from either side, until they became horizontal in the plains. On the east side of the main



A portion of the East face of Gothic Mt. showing the relations of the Eruptive Rocks to the Cretaceous Shales.

range, in the South Park range, the eruptive groups have thrown the sedimentary beds into the utmost confusion, producing those remarkable faults and irregularities which were shown in the annual report for 1873. On the west side, in the Elk Mountains, the confusion is still greater, producing not only the most remarkable faults in all the western country, but literally overturning thousands of feet of strata. By examining the preliminary map of Colorado in this report, it will be seen that the trend of the Sawatch range is very nearly north and south, and that the principal peaks from the Mountain of the Holy Cross at the north to Mount Ouray to the south lie along that line. The trend of the Elk group, though less regular, will be seen to be about northwest and southeast. This is a grand illustration of an eruptive range, and appears also to be an example of a sudden violent or catastrophic action. The immense faults, complete overturning of thousands of feet of strata, and the great number of peaks, all composed of eruptive rocks, indicate, perhaps, periodical and violent action in contradistinction to long-continued uniform movements of the elevatory forces. The sections and maps which accompany this report will doubtless enable the geologist to determine the correctness of our statements. The map will show by the colors the eruptive points, where the granite appears to have been thrust up, as it were, through the vast overlying crust; sometimes a great thickness of strata of various ages is carried up to the summits of the peaks, 13,000 or 14,000 feet in elevation above the sea. Again we find, but a few yards away, the same group of strata in the bottom of the lowest valleys, indicating remarkable convulsive movements. Although the Elk group may be regarded as an eruptive range, it will be seen by the map and section that the elevatory forces, whether convulsive or uniform and slow, acted along a well-defined axis, thus, as a range, forming a true anticlinal.

We see, therefore, that the eruptive agents acted along a great fissure in the earth's crust as a line of greatest weakness, and that this line possessed a trend about northwest and southeast. But the peculiar nature of the forces produced the wonderful chaos in the position of the sedimentary beds, while the tendency of these strata is to incline from either side of the axis. It is not uncommon to find thousands of feet of strata which have been carried up to the loftiest points of the axial ridge in nearly or quite a horizontal position. We may suppose that at one period the vast sedimentary mass rested on a floor of pasty or semi-pasty granite; that the forces in the interior were struggling to find vent, carried upward the entire overlying mass of sedimentary strata, and that here and there many thousands of feet in thickness along the axial line or ridge was thrust up through the melted or semi-melted granite in such masses as are shown on the map, at Italia, White Rock, Snow Mass, Capitol and Sopris Peaks. The map will show that this igneous granite does not reveal itself except along this quite regular axial line. The areas of granite are greatly enlarged by subsequent erosive action, while from the axis numerous streams cut deep gorges, 1,500 to 3,000 feet in depth, sometimes far into the underlying floor of igneous granite. During this period of revolution, and probably subsequently, there were great numbers of dykes or orifices from which issued the rhyolites and basalts. Gothic and Crested peaks are illustrations of the upthrust of vast masses of rhyolite, and numerous other quite long dykes will be noticed on the map.

Plate XIV represents a portion of the east face of Gothic Mountain, the central mass of which is rhyolite, with only the Cretaceous beds lifted up around the base and sides. This is an excellent example of these

remarkable upthrusts of igneous material, vertically through the overlying sedimentary beds. The Cretaceous strata of Nos. 3 and 4 extend up on the sides of the peak about 1,000 feet above the bed of East River, with very little inclination, and between the strata of shale were pressed out portions of the igneous material.

The illustration, Plate XIV, is so clear that but little space need be used in explanations. The shale all belongs to Cretaceous formation No. 4. An examination of the map and plate of sections would indicate that the aggregate force which elevated the Elk range acted vertically with a tangential movement or shove, as it were, from the northeast toward the southwest. There are many faults of remarkable character on the northeast side of the axis, but no very marked examples of the inversion of strata, but on the southwest side of the axis this feature is shown in a marked degree. Time will not permit us to work out in detail in this report the wonderful complications in the strata, which have been produced by the various elevating forces in this range. Much of it was brought out in the various reports in the annual report of the survey for 1873. Mr. Holmes will also introduce important details into his report. I shall, therefore, at this time, confine myself to a general view of the geology of this range, which, with the beautiful and remarkably clear illustrations, will be sufficient for the information of the geologist.

The axis of the Elk range can be easily traced on the map, and the axial section will show the immense masses of strata that were carried high up to the very summits of the range.

At the southeast corner of the map it will be observed there is a considerable area designated as metamorphic granite. This forms a part of the Sawatch Mountains, and may serve to show the relations of that range. To the west of it there are narrow belts, marked as Silurian and Carboniferous. These represent masses of strata that were originally lifted up by the Sawatch range and incline toward the west. On the completed geological map of Colorado, the connection of these fragmentary masses of sedimentary strata about the summits of the high granite mountains will be made clear. We shall hereafter attempt to show by a series of sections, not only that the Triassic, Jurassic, and Cretaceous groups originally existed here in full force, but that they probably extended across the area now occupied by the Sawatch range and were united with the sedimentary beds of the South Park range.

The northeastern slope of the Elk group slopes down into the valley of the Roaring Fork, an important branch of Grand River. Here we find a large area of the various divisions of the Cretaceous group. The Dakota group rests upon the Jurassic, but is not exposed to any great extent, except in the cañons or gorges of the streams. So far, therefore, as a map is concerned, it cannot be represented except by a very narrow band, but above it there is from 1,000 to 1,500 feet of the remaining portions of the group, Nos. 2, 3, 4, and 5, but not as well defined even as on the eastern side of the Colorado or Front range. The greater portion is composed of black shaly clays with thick beds of sandstones appearing in different positions. A few Cretaceous fossils occur, of well-known and common genera, as *Ammonites*, *Baculites*, and *Inoceramus*. Very few of the smaller forms were observed. This singular Cretaceous area seems now to form a sort of basin with the Jurassic and Triassic, or Red Beds all around it. Its peculiar form will be noticed on the map. The Cretaceous beds occupy very varied positions, sometimes high up on the mountain-sides nearly to the summits, and then filling up the lower valleys. The faults are without number, for in the process of elevation the strata seem to have been

broken in every direction. The aggregate inclination, however, is always to the northeast. This great mass of Cretaceous beds were influenced by the operations of two quite distinct elevatory forces which probably acted synchronously, so far as forces so different could act. To the eastward the long ridges of the Triassic and Carboniferous Red Beds extend down to the west from the axis of the Sawatch range, cut into deep cañons, the waters of which flow into the Grand River. These Red Beds were elevated by the Sawatch range, while the Roaring Fork flows through a sort of anticlinal valley between the axis of the Elk and the Sawatch Mountains. These Cretaceous beds form a sort of an island or basin between these great axes, and therefore lie in the synclinal. It is by means of the more modern beds, as the Cretaceous group, that the anticlinal character of the mountain range is more clearly seen. The Triassic and the Carboniferous beds extend over the axis of the range, while the granite nucleus makes its appearance only in limited areas, as at Sopris, Capitol, Snow Mass, and White Rock peaks. Between Capitol and Sopris peaks there is a long distance where the Red Beds form the axial ridge entirely, and seem to hold for the most part a horizontal position. On the map the Red Beds or Triassic and the Carboniferous groups are thrown together, from the fact that we found very great difficulty in separating them. Not only is there no apparent break in the sequence of the strata, but they are so mingled together in the uplifts and overturnings that it would have required more detailed study of the range to separate them entirely than we were able to give at that time. Co-extensive with the narrow belt of the Dakota group, is a light band which represents the Jurassic group. Neither of these formations is ever exposed over large areas, usually only in outcropping edges along the margins of the mountain, or in the sides of the cañons. The Silurian group, so far as it is known in this region, always rests directly on the granites, whether igneous or metamorphic, and is, therefore, confined mostly to an outcropping belt around the granite areas. On the west and southwest sides of the axis the Cretaceous group appears again, extending far beyond the limits of the map. Its relations to the axis are such as to show plainly that, like the older formations, it formerly extended in an unbroken mass across the area of the Elk range. There can be no doubt of the original continuity of the entire mass of the sedimentary strata. North and west of Sopris Peak the country slopes off toward the Colorado River, and the surface is gashed deeply with the gorges of the streams which cut through the Cretaceous beds, oftentimes into the older groups. The Cretaceous strata, however, predominate.

In the annual report for 1873, the tremendous effects of erosion, as shown on the west side of the Elk Mountains, were described in detail. These effects are displayed even on a still grander scale on the east side of the range. The gorges or cañons cut by Castle and Maroon Creeks and their branches, are probably without a parallel for ruggedness, depth, and picturesque beauty in any portion of the West. The great variety of colors of the rocks, the remarkable and unique forms of the peaks, and the extreme ruggedness, all conspire to impress the beholder with wonder. The illustration, given in the northeast corner of the map, of Castle group is a type of the scenery at the heads of these streams. We here see from 3,000 to 5,000 feet of stratified rocks lifted up vertically so that the beds are horizontal, or nearly so, presenting to the eye, by the eroded forms, a wilderness of pyramidal cones whose summits rise to a height of 13,000 and 14,000 feet. The sides of the cañons are vertical or nearly so, displaying a continuous section of the

strata 2,500 to 3,000 feet, composed of alternate beds of sandstones and conglomerates with thin layers of clay or shale. These sandstones vary very much in structure in the same layer, from a fine-grained sandstone or quartzite to a rather coarse conglomerate. These changes may occur in different portions of the same layer or at different positions in the same group of strata. The lower portion of the cañon is composed of rather compact sandstones, but toward the summit the rocks become a brick-red and are formed of rather loose sandy material. All the rocks vary in color from a dark dull purple to a brick-red, depending much on the influence of heat. There is a considerable degree of change in these rocks from heat, but only in a few cases amounting to complete metamorphism. These massive walls and pyramids are often intersected with dikes which have filled either vertical fissures or not unfrequently have been thrust between strata, forming local beds of rhyolite, sometimes of great thickness. The dividing ridge forms a curious zigzag line, often so narrow as to be almost impassable to one on foot.

Enormous amphitheaters have been slowly carved out of the dividing ridge at the head of each little branch. Without speculating upon the character of the forces which were at work here in the far past, whether they were far more intense in their action than at present, we may infer that at this time they operate exceedingly slow. Portions of the dividing wall are falling all the time, from the influence of frost or water, and in many instances the amphitheaters extending back over the true divide, sometimes even breaking through the axial ridge. Usually a vast accumulation of *débris* may be found damming up the gorge at various distances from the immediate head of the amphitheater, thus giving origin to a small lake, the waters of which gradually soak through the *débris*, and, coming out on the lower side, gather into a small stream. It seems hardly possible that at the present time there are any agents in existence that could have transported this *débris* down the gorge. It must have required a considerable quantity of water, with large masses of snow or ice, for the *debris* is often composed of large masses of rock that could only have been moved by floating ice. In the valley of Roaring Fork, the morainal deposits are remarkable for their thickness. The surface is covered with huge bowlders, some angular and others partially rounded. The terraces are very conspicuous, rising, in some instances, to 1,000 feet or more above the bed of the stream and strewed over with huge bowlders. None of the stray materials in any of these valleys or gorges seem to have been transported a very great distance, and never, under any circumstances, is there any drift or glacial deposits from a neighboring drainage; in other words, the loose material does not pass from one independent valley to another. So it is all over the Rocky Mountain region so far as I have observed. All the drift or Post-pliocene deposits are local.

I regret that, for want of time, this meager account of so important a range of mountains must be closed. In the final report, in quarto, which will accompany the atlas of maps, we hope to present a more careful review of each range of mountains, with their relations to each other.

In this report I have attempted to number the plates in consecutive order, but the sheets of sections and maps could not be so numbered, but will probably be clearly understood.

CHAPTER VI.

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REPORT ON THE GEOLOGY OF THE NORTHWESTERN PORTION OF THE ELK RANGE.

BY W. H. HOLMES.

DEAR SIR: In accordance with instructions received from you, I continued the geologic examination of the northwest portion of the Elk Mountains, and beg leave to present the following report:

When it was found that, on account of the sickness of Mr. Shanks, assistant topographer, the main party could not advance beyond Capitol Creek, a small party, consisting of Mr. George B. Chittenden, topographer, myself, and one packer, was detailed to continue the survey around to the northwest.

It was arranged that we should carry with us provisions for fifteen days, and that a supply-party should meet us on the western side of the range, near the sources of East River, if the main party should not be able to reach that point in time.

On the 29th day of August, we left the main camp and moved down the valley of Roaring Fork. A well-marked Indian trail led us through a low, synclinal depression, which is separated from the channel occupied by the river, by a long, narrow ridge or hog-back. The depression is occupied by the Lower Cretaceous shales, and the sandstones of the Dakota group form the crest of the ridge.

We soon crossed a low divide and were upon the southern branch of Sopris Creek. This stream heads near the summit of the Elk range, midway between Capitol and Sopris peaks, and on reaching the deepest part of the depression, turns abruptly to the northwest and cuts obliquely down through the ridge of Cretaceous, Jurassic, and Triassic rocks.

The main Sopris Creek is formed in the snow-filled amphitheaters about the eastern faces of Sopris peak and descends to the valley with great rapidity, falling 6,000 feet in less than eight miles. It cuts its way out from the granite to the Cretaceous rocks and then descends with the dip of the beds, flowing for some time upon the hard floor of the Dakota sandstones. The bed of the creek is everywhere very shallow, and I was unable to determine whether any rocks lower than the Jurassic were exposed or not. Dr. Peale, who climbed Sopris peak from this side in 1873, states that there is but little exposure of the sedimentary rocks along the north and northeast faces of the mountain, on account of the great quantities of *débris* and morainal drift.

THE ROARING FORK SYNCLINAL.

Before passing on to the description of Rock Creek and the western slope, I wish to take a hasty review of the general geology of the valley of Roaring Fork, and give, if possible, a connected idea of its structure. This valley is throughout, so far as examined, in the trough of a synclinal fold, and its entire conformation, the course and form of the main valley as well as of all its tributaries, is undoubtedly the result of this

geologic condition. The depression is by no means uniform, and the movements of the stream-bed are quite eccentric, making altogether a very interesting study.

From the mouth of Maroon Creek to the mouth of Sopris Creek, a distance of some twelve miles, there is a pretty well marked fault, not following the line of greatest depression, but occurring along the eastern slope from one-fourth to three-fourths of a mile from the axis of the fold. We thus have a fracture parallel with a fold, and the two lines seem to contend for the privilege of accommodating the stream-bed. Above Maroon Creek (see map and sections) the river flows in the synclinal; near the mouth of the same creek, it is in the fault. Below this it cuts through the beds again and follows the synclinal for a number of miles. Still lower it turns again to the right, into the fault, and follows it all along the eastern base of the isolated ridge mentioned at the outset. Leaving this again below the mouth of Sopris Creek, it continues in the fold, while the fault probably dies away. The dislocation, if any, of the beds, as exposed on opposite sides of the stream, is so slight that it seems quite impossible to determine this point. The downthrow is generally on the west, and does not amount in any case to more than 3,000 feet. In two localities along the fault, there have been outflows of lava. These were observed by Dr. Peale, in 1873, and are located, the lower one, opposite the mouth of Sopris Creek, where it caps a large rounded butte, (see general map.) The other is on the same side of the river, some five miles farther up. The lava appears to be basaltic, and has quantities of cinder and ashes associated with it. It caps an important butte near the river-bank, forms an escarpment some 100 feet in height, and covers an area of scarcely more than half a square mile. Section C of the large sheet cuts this butte, and shows at the same time a most remarkable displacement, the edges of the strata on both sides of the fault being turned abruptly up, and therefore dipping from the plane of the fault, both toward the upthrow and the downthrow. The beds on the west side are depressed so that the Lower Cretaceous rocks seem to face the Upper Carboniferous of the east side. The upturned edges were apparently leveled off before the flow of lava took place. At the mouth of Maroon Creek the depression of the west side has been much greater, and the edges of the beds have been dragged upward and, apparently by a lateral movement, forced past the vertical. Thus is formed the little butte of Cretaceous and Jurassic rocks between Maroon Creek and Roaring Fork, at the junction described by Dr. Peale, (Report for 1873, page 263.) Shortly above this the fault becomes a fold and so continues up the valley of Castle Creek.

The sections of the accompanying plate, Fig. 1, cut ten of the most interesting points along the line of disturbance, and is intended to give a connected idea of the folding and dislocations. The sections are so placed as to give the impression that perspective is taken into account and that the point of view is somewhere on the lower course of Roaring Fork. It will be observed, by reference to these, that the southern extension of the synclinal follows the valley of Castle Creek, and that the upper course of Roaring Fork proper is in the granite to the east. A still more extended examination to the southward and beyond the sources of Castle Creek, seems to warrant the conclusion that the portions of Silurian (?) quartzite noticed on the east face of station 3 and along the summit of the Italian group beyond, indicate a continuation of the same fold or at least of the same movements that produced the fold. That this is the case, and, therefore, that the entire geologic phenomena of

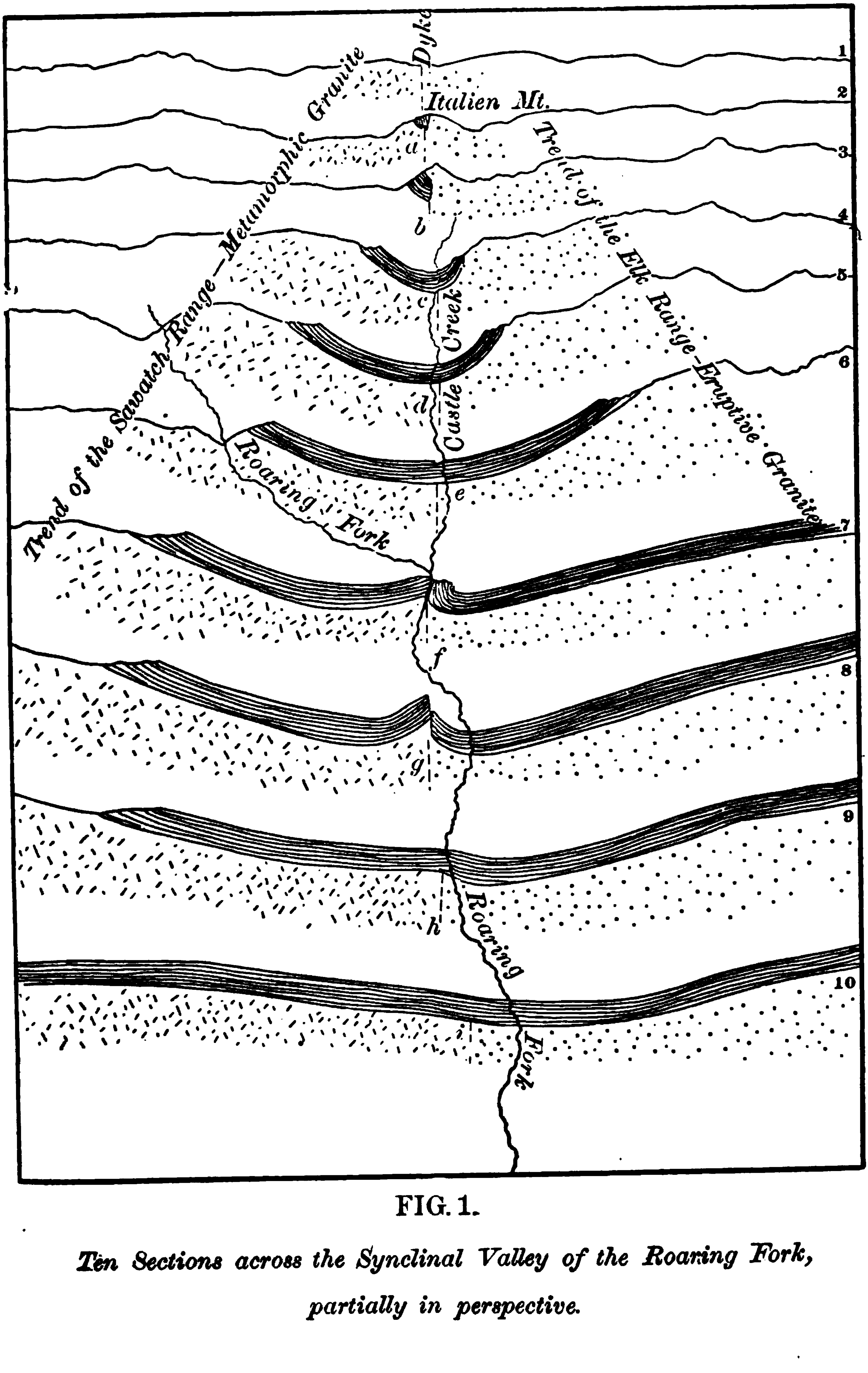

FIG. 1.

Ten Sections across the Synclinal Valley of the Roaring Fork, partially in perspective.

this region are connected, and, generally speaking, not the result of complicated causes, may be pretty conclusively shown.

It must be noticed, in the first place, that on the east side the sedimentary strata lie up against the granite of the Sawatch range, and that on the west they have been carried high up on the arch of the Elk Mountains, leaving the synclinal depression between the ranges. In the second place, that the axes of the two ranges are not parallel; that they approach each other toward the south and separate toward the north, giving an included angle of some 30°. In the vicinity of Italian peak the granites of the two ranges are in contact, or nearly so, as seen at *a* in section 2. On station 3, a few miles farther north, a fragment of the Paleozoic rock is caught up and held, as in a vice, between the masses of eruptive and metamorphic granite, *b*, section 3. North of this, down the valley of Castle Creek, the sedimentary area widens rapidly. The edges facing the Castle group are bent up at a sharp angle, but as the fold widens it also flattens, so that 30 miles north of Italian Mountain, near the line of section 10, the belt of strata is 25 miles wide and has nowhere a dip greater than 10° or 12°.

In the plate I have indicated the two granites by different symbols, the metamorphic by short broken lines and the Elk Mountain granite by dots. The points of contact, as shown at *a*, *b*, *c*, &c., are, of course, only given to indicate a probable contact line. That such a separation really exists, however, is evident from the fact that when observed in close contact, near Italian Mountain, they are totally distinct in appearance and in reality. In all its general features, the geology of the valley of Roaring Fork and of the eastern slope of the Elk Mountains, seems simple enough, and I shall hasten on to the north and west.

GEOLOGY OF SOPRIS PEAK AND VICINITY.

Having ascended Sopris Creek for some five or six miles, we turned abruptly to the right and crossed the low divide that connects Sopris peak with an outlying triangular spur, and descended by a deep gulch into the valley of Rock Creek. We reached this creek at the point where the upturned edges of Cretaceous No. 1 (Dakota group) cross, and found that our descent had been almost with the strike of the beds, N. 40° W. This is on the west slope of the Roaring Fork synclinal, and the dip is therefore to the east. The creek passes out into the Cretaceous shales and reaches the river some eight or nine miles below. The crossing of No. 1 here marks the foot of the cañon of Rock Creek.

Beneath No. 1, on the south side, a very beautiful section of the Jurassic is exposed. Near the summit of the bluff, about 200 feet of the Lower Cretaceous measures are exposed, consisting principally of compact yellowish sandstones. Some thin beds of shale are interstratified with the sandstones, and near the base there is an irregular stratum of moderately coarse conglomerate. The Jurassic section, beginning at the top, is as follows:

20 feet shales, containing seams of greenish and purplish quartzite. The shales weather like fire-clay.
6 feet thinly laminated, fine-grained, flinty quartzite.
10 feet yellowish quartzite.
80 feet shales and calcareous sandstones.
40 feet sandstones and sand shales.
40 feet yellowish sandstone with layers of gypsum.
Red shales and red sandstones of indefinite thickness.

From the trail, near the creek-bed, a very fine view of this cliff is

obtained. Weathered into the usual forms produced by alternate hard and soft beds, it begins at the top, by an escarpment of the yellow sandstones of No. 1, passing down into purplish and greenish grays, broken by darker lines of outcrop, each of which gives a tinge of its own color to the already highly-tinted slide, and still farther down the wide band of rich yellow transforms all to its own hue, and the whole sweeps down like a gorgeous curtain over the bright red cliffs of the Triassic (?). The closest search developed no trace of fossils, and it is of course impossible to define the limits of the several periods. The lithologic gradation here, from the Jurassic down through the "Red Beds" into the well-established Carboniferous is most perfect, and the entire absence of fossil-remains leaves us without a clue.

In passing up Rock Creek we descend through the strata and on either hand find the cañon-walls composed of the red and maroon Carboniferous series. On the left they support the Sopris mass, which stands some miles back, and on the right rise into a cluster of rugged hills, above and beyond which are the lines of Cretaceous outcrop, apparently dipping to the westward. In the bottom of the cañon the maroon beds seem, very oddly, to dip toward the Sopris uplift as if not affected by it, but by some movement farther to the west, but they are doubtless folded abruptly up against the northwest face of that mountain. Close under the west walls of Sopris the creek forks. At this point the granite appears, and may be seen, from far below, rising in rugged walls and abrupt spurs. The two branches seem to emerge from the base of these as immense springs, but by a closer approach we could detect the cañons through which they flow. They are cut like great gashes through the granite, having between them a high promontory.

On the 30th of August we ascended this promontory, and found it to be a very excellent point of observation (station 22). The peak lies to the east, rising very abruptly from the creek and presenting an astonishing mountain-slope. The creek-bed is 6,000 feet above the sea, and the peak springs to the height of 12,800 feet in one precipitous, unbroken slope, a rise of 6,800 feet in one and a half miles. With the exception of this western tongue, the granite mass seems to be a perfect cone that has had its apex pushed through the sedimentary strata, lifting them up abruptly all around, but in no case affecting them outside of a radius of three or four miles. Indeed, if the erosion had been more equal on all sides the exposed granite area must have been nearly circular, but the great erosion of Rock Creek cutting so deeply into the mountain-side, has developed an area something like that shown in Fig. 2.

This elevated area forms the extreme northwest end of the Elk range, and is connected with the *Capitol* and *Snow Mass* groups, which lie about ten miles southeast, by a high, red ridge, the crest of an arch in the Carboniferous rocks, which here connect completely across the range. The more recent strata have been broken down and carried away, so that their outcropping edges are ranged low down along the flanks of the mountains, on the east side trending toward the northwest, making almost a tangent with the Sopris granites, crossing Rock Creek at the point where we entered the valley, and swinging around to the north indefinitely, but, very probably connecting, in the low country, with the corresponding series of the west side.

The east branch of Rock Creek, which I have called Avalanche Creek, heads in the northern and western faces of the Snow Mass group, and has cut its way in a most remarkable manner down through the side of the red arch, almost parallel with its crest, striking Sopris

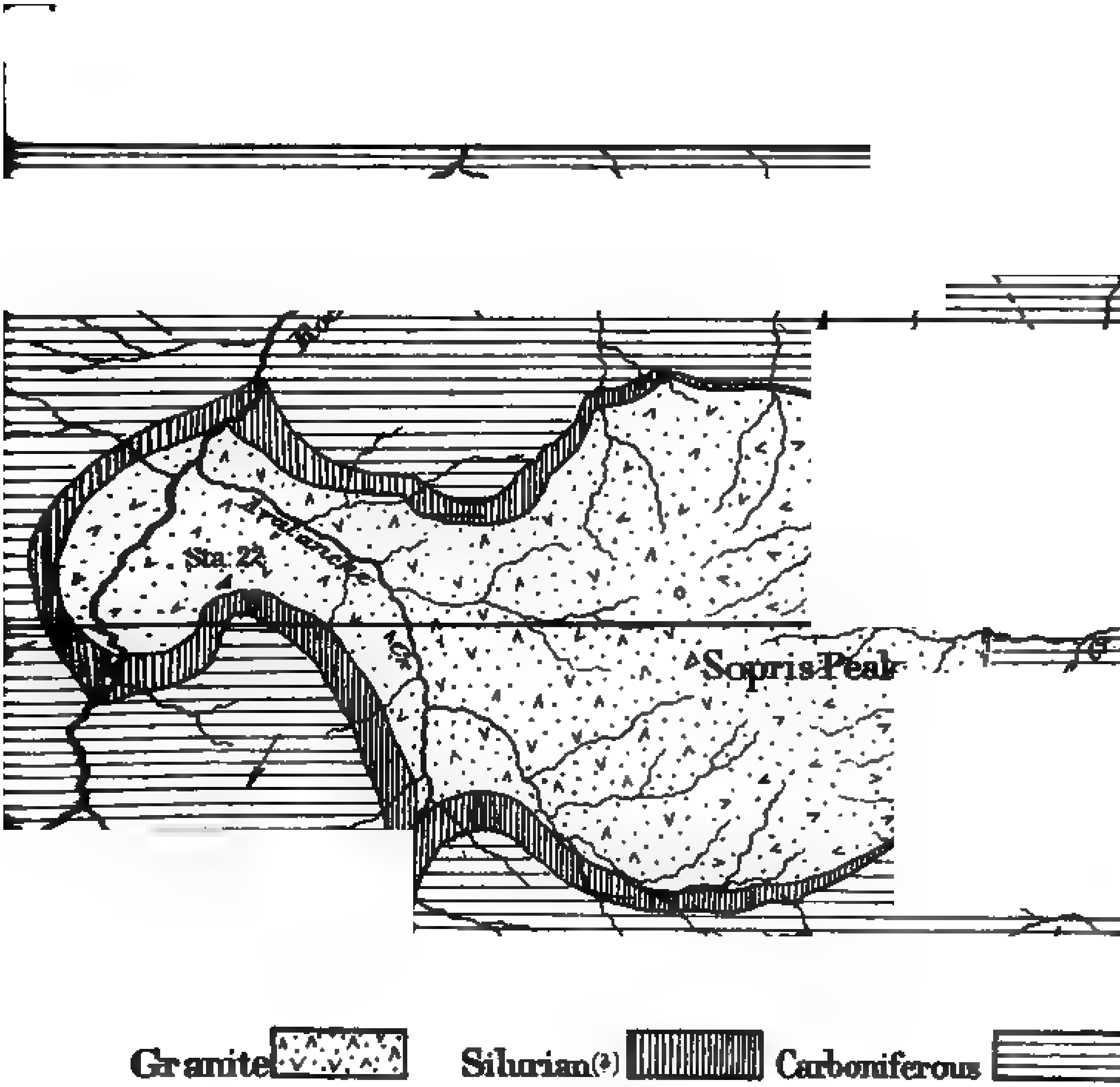

Fig. 2.

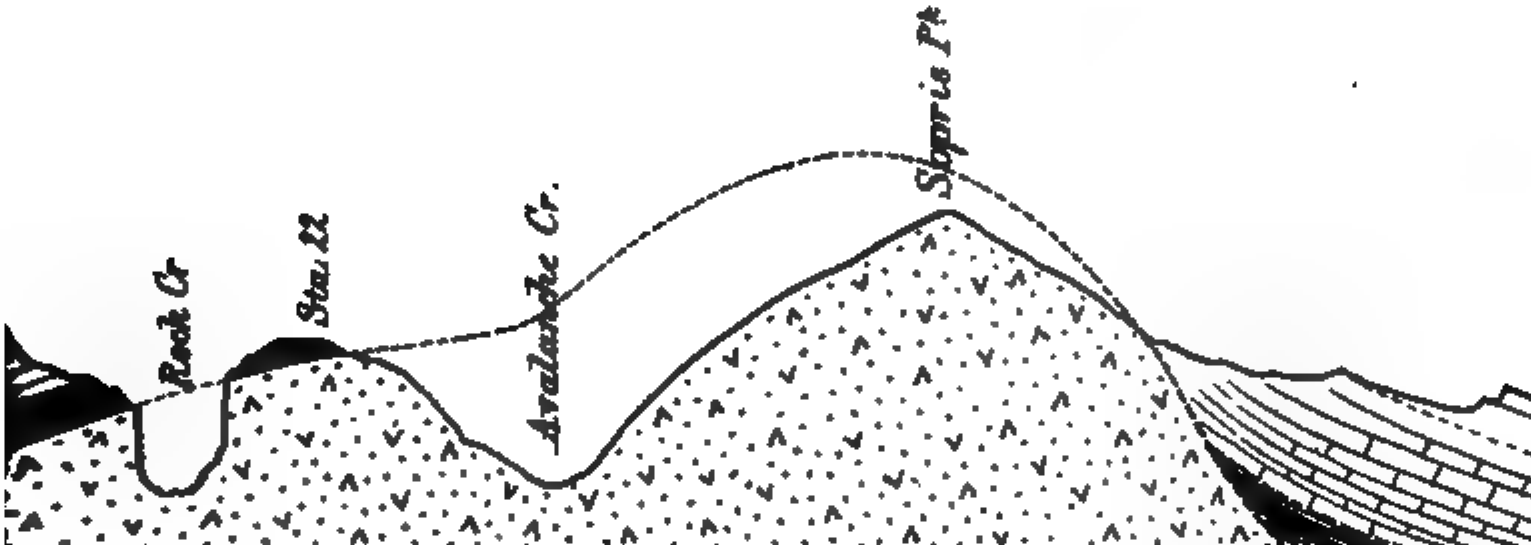

Fig. 3.

Section across the Sopris uplift.

Fig. 4.

Sketch. Looking down Rock Creek from Promontory Point. – Station 22.

a, Junction of East and West Forks Rock Creek. c, Cañon of Grand River. e,e, Silurian(?) Quartzites g,g, Cretaceous No. 1. The point where Rock Creek was first reached.
b, Junction of Rock Creek and Roaring Fork. d,d, Granite of Sopris. f,f, Carboniferous Strata. The Jurassic Section already given is at g'.

between our station and the main summit, and joining the main stream below. In the upper course, therefore, it is in granite, in the middle part, in Paleozoic rocks, afterward in granite, and finally again in the stratified rocks, cutting its way, after joining the main stream, from the Silurian out into the Upper Cretaceous. Rock Creek proper, the sources of which were explored last year, can be traced far to the southward, as it comes down through a deep valley. This valley widens as it approaches our station, but on reaching the belt of granite, suddenly closes into a deep and precipitous cañon. This is immediately under us, to the west, and a stone dislodged plunges down over the crags to the creek-bed, 1,500 feet below. This cañon is hardly more than half a mile in length (the width of the granite arm) and opens below into the great triangular valley about the creek junction.

The sketch on the opposite page, Figure 4, will aid in making clear the geology north of our station, and about Sopris. As seen in the drawing, there is considerable irregularity in the disposition of strata. The isolated fragment of Paleozoic beds between Sopris and Rock Creek evinces a considerable amount of lateral crushing as indicated by a series of abrupt and angular concentric folds or wrinkles. Along the line of the creek-bed there has probably been a slight dislocation or fault as indicated by the want of harmony between the strata at e'' on the east side, and those at e''' on the western. There are also traces of a considerable degree of metamorphism, shown by the change of color near the granite contact, as well as by the thinning-out of the entire series, such as would occur in a number of sheets of iron heated and partially welded together at the edges under the irregular blows of a hammer. It has been suggested that the existence of a shore-line about the granitic area has, during Paleozoic times, produced this thinning-out, and especially since, on the eastern face of the mountain, the more modern deposits seem to jut up against or almost against the granite, but it should be observed that in every locality where this peculiar granite appears, there are unmistakable evidences of abrupt and violent movements, independent of its relations to the sedimentary strata. It acts in all cases as a foreign element, plastic and aggressive, intruding itself upon a region heretofore undisturbed, and producing disturbances of the most marked and unusual kind. In this case, however, there is less evidence of violence than in any of the cases farther south, but in lithologic character and methods of upheaval it is the same.

GEOLOGY OF THE DISTRICT DRAINED BY ROCK CREEK.

We had resolved to follow the course of the western or main branch of Rock Creek. In the cañon there was an old trail leading over the rocks, and we passed through, without difficulty, into the open valley above. Here were some beautiful meadows in which we discovered a group of hot springs. In a number of places, steam could be seen rising from the grass and reeds, and on approaching we encountered a number of slimy pools, from which considerable streams of hot water were flowing. In all there were more than a dozen active springs, in most cases impregnated with sulphur, and ranging, in temperature, from 30° to 104° F.

On the 29th a rain-storm had set in, and everything was now wet, thoroughly saturated. Muddy torrents poured down the upper slopes and dashed over the cliffs into the valley. Avalanches of wet earth, carrying many rocks and trees, formed near the summits and came roaring down, discharging their great masses of *débris* into the river, and

tearing out such gorges in the alluvial bottoms as to make travel almost impossible. The continuation of this sliding process from year to year keeps large portions of the mountain-sides swept clear of all movable material, leaving only the bare rock. All along these deep valleys such avalanche-pathways may be noticed.

The vegetable growth is quite profuse in this region. Dense groves of aspens occupy the more fertile spots, pines and cedars cling to the rocky slopes, while scrub-oaks and a great variety of smaller bushes abound. There is but little room for agriculture or grazing.

At the upper end of the cañon the granite disappears and the yellow quartzites descend into the valley and also disappear, dipping 30° S. The Carboniferous maroon beds follow, but soon assume a horizontal position, so that there is nothing else exposed in the walls, for a distance of five or six miles. Then, by an abrupt monoclinal fold, the whole series pitches into the valley, leaving nothing exposed but the massive sandstones of the Upper Cretaceous. These beds in turn assume a horizontal position, forming shelved slopes to the height of 1,200 to 1,500 feet on either side of the creek. The creek cuts obliquely through this fold, and the section exposed consists of the Upper Carboniferous, Jurassic, and Lower Cretaceous strata. On the left hand the hard layers of the Dakota group, standing almost on edge, form a high ridge that extends to the southward up the western slope of the Snow Mass group. On the opposite side, the trend of the same beds is to the northwest, passing up the face of a high mountainous ridge which culminates in Gannett's station 26, ten miles west of Sopris. Section C of the large sheets cuts this fold near the creek-crossing, and also gives a transverse section of the great red arch which lies between Sopris and Capitol peaks.

The facilities for measuring the strata in this locality are very poor. The yellow quartzites, supposed to belong to the Silurian age, do not measure more than 500 feet, while the Carboniferous series will hardly fall short of 4,500. The Triassic (?), Jurassic, and Cretaceous beds will add about 5,500 more, so that the exposed strata will include a thickness of some 10,000 feet.

Ever since entering the valley a handsome group of mountains had been in sight, apparently standing in the valley-course, and quite cutting off the view. From the crossing of the monoclinal fold, the first of these mountains appeared three or four miles farther up, standing on the west side of the valley, and rising abruptly from the creek. We determined to climb this in order to get good views of the Elk Mountains, which lie mostly to the east, and of the unknown area to the west.

In the first place, we ascended the steep Cretaceous slope to the right, at its lowest point, and found ourselves on a level with the undulating country to the west. Gannett's station 26, was on our right, some ten miles to the north, and the mountain which we desired to climb on the left, three miles away, and rising nearly three thousand feet above us. Following the summit, or back of the ridge which leads up toward it, I observed that the Cretaceous strata were rising with the slope, and at the base of the steeper face were turned sharply up against it at an angle of 45°. In crossing these upturned edges, I observed that they comprised no great thickness; that the bulk of the sedimentary beds seemed not to change from their horizontal position, and that this upturned portion had been separated from the rest and forced upward by a wedge-like mass of intrusive rock which belonged to the central mass of the group. (See Figure 5.) These strata seem to belong to the Cretaceous Coal Measures, as there were outcrops of coal and carbonaceous shale. The horizon would hardly be less than 3,000 feet above No. 1.

Fig. 5.

a, Station 23, Rhyolitic, intruded as a wedge between the upper cretaceous strata; b, b' and c, c'
Figure 7 connects with this at the left.

The rock of the peak proved to be an exceedingly fine and handsome rhyolite, grayish in color, and containing many large crystals of white feldspar.

Station 23 was made near the highest point. This proved, as I had expected, to be the extreme northern summit of the large group of mountains that lies to the west of the Elk Mountains proper, and may for convenience be called the West Elk group. It is hardly inferior to the main range in area, and is separated from it by the valleys of Rock Creek and East River. Clusters of handsome, moderately high summits could be seen far to the southward, and as far toward the east as Treasury or Lookout Mountains. The general outlines and the manner of weathering indicate that they are all of trachyte or rhyolite.

To the westward the country is low, and slopes off toward the Gunnison River on the left, and the Grand on the right. There are no striking geographical features, and the whole visible area is doubtless of Cretaceous age, the exposed rock being mostly of the Upper Cretaceous group, which comprises perhaps 2,500 feet in thickness of sandstones, conglomerates and shales, with an undetermined number of coal-seams.

As mentioned before, the main body of the stratified rocks about this station are not disturbed, so that the exposures all along the eastern base, beneath the body of trachyte, are horizontal, and so continue far up Rock Creek. This creek heads in a picturesque group of mountains far away to the east, cuts its way down through a number of deep cañons, and striking the base of this mountain turns abruptly to the north. From this point we get our first view of the western faces of the Elk Mountains, and are impressed more deeply than ever with their beauty and grandeur. The lower slopes are underlaid by Cretaceous strata and densely covered by a growth of gray and purple underbrush. Above this, groves of aspens and clusters of dark blue pines relieve the glowing reds and purples of the Carboniferous rocks. Still higher, and in delightful contrast to these ardent colors, are the summits of gray granite, whose polished and ornate faces constantly remind us of the form in some gothic cathedral. The culminating summits belong to the Snow Mass group, and are so thoroughly hemmed in by serrated crests, and deep zigzagging ridges, that they seem to challenge approach. In a few days we hope to penetrate the obscure valleys that head in this group, and from some of its higher peaks make a more detailed study of its forms and structure.

We found the ascent of Rock Creek beset with difficulties, and only succeeded in advancing at all by climbing the eastern wall of the cañon and remaining on a flat, shelf-like area, formed by the horizontal Cretaceous strata. In the middle of the afternoon of September 1st, we descended into the bed of a small tributary of Rock Creek, not far below the base of Treasury Mountain. In passing down the face of the upper ledge I observed that the rock was of rhyolite, and not sandstone, as I had supposed. This proved to be only a capping, and is doubtless a remnant, separated from the mass west of the creek by erosion, since both walls of the valley, up to corresponding horizons, are of Cretaceous shales.

The creek into which we had descended seemed to issue from the very center of the Snow Mass group, and finding a pretty distinct game-trail we turned to the left and followed it up the valley. On our left hand a steep bluff rose to the height of some 1,500 feet. The strata exposed in its face were probably of the Upper Cretaceous group, and consisted of sandstones and shales, the former predominating above and the latter

below, so that there was a gradation from solid sandstones at the top to homogeneous shales at the base. The section includes the group of strata sometimes called the "transition group" by Dr. Hayden. The horizon is probably that of the upper part of No. 5, Cretaceous. The dip of the beds in this place is toward the northwest 10° to 15°. They seem but slightly affected by the elevation of the main range on the east, or of Treasury Mountain on the south. Farther up the stream, which we shall call Aspen Creek, the dip increases to 45°, and the upturned edges are lodged against the granite, which, by means of a rather complicated fault, has been thrust up past the broken edges of the entire series of earlier sedimentary rocks, bending the edges of the older strata back and driving them into the softer strata above. In the bottom of the creek a small portion of the yellow quartzites are exposed, situated as shown in Section D of the large sheet. This fault would seem to be on the northern continuation of the line of upheaval to which belongs the inverted series observed last year about the southern sources of Rock Creek. Our investigations at that time were extended to within six miles of this point.

Late in the evening we encamped near timber-line, and on the following morning climbed the high granite ridge to our left. We soon found ourselves in the very midst of the mountains. Snow Mass and Capitol and Mount Daly rose up magnificently in the east, Sopris stood alone at the north, and many groups of lofty mountains appeared in the southwest. All around us were only bare rock and snow. The whole area is above timber-line, and the sculpture of the mountains is wonderfully striking and picturesque. The long crooked lines of crests are connected by subordinate crests, and these all send out sharp, narrow branching ridges which separate the amphitheater-like heads of the numerous radiating streams. As a rule, these high valleys are wide and the ridges narrow, so that the country presents the appearance, in a rude way, of a giant honeycomb. Sopris is connected with Capitol by the flat ridge of Carboniferous red beds, Capitol with Snow Mass by a deeply-indented saddle, while south from Snow Mass, the axis crest continues to Maroon Mountain, thence to the White Rock and Castle peaks. From the saddle, midway between Capitol and Snow Mass, a pinnacled ridge extends to the westward between the head-waters of East Fork or Avalanche Creek and Rock Creek proper. Branches are thrown out from this between all the small streams, while the chief crest of the spur continues out to station 22. Stations 24 and 25 were made about midway on this ridge. Station 24 is the most northerly summit of the Snow Mass granite, and is eight miles from station 22. The sedimentary outcrops, which pass just north of Capitol and Daly peaks, sweep around to the north of this station and turn to the southward, crossing Aspen Creek, as described on the preceding page. Here the entire series is exposed, there only the Upper Cretaceous and bits of the Paleozoic rocks in the bed of the creek. The lines of outcrop can be traced between the two points. The older rocks gradually disappear as the granite begins to fault up past the broken edges. (See colored map). This may be regarded as the farthest northern extension of the great fault-fold previously mentioned. This fold being a most complicated and interesting piece of dynamics, calls for a separate analysis, which I give farther on.

On the 3d we descended Aspen Creek to the main creek and continued the examination of the Cretaceous section. The black shales, the upper part of which are exposed in the bluff on the north side of Aspen Creek, occupy the valley from the base of the bluff to the base of Treasury

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Fig. 2

Treasury Mountain

a. a. Treasury Mt. – quaquaversal. — b. east branch of Rock Creek – c. south branch. — d. d. Junction. — e. e. e. outcrops of Shales of No 2 and circling the north end of Treasury Mt. f. f. f. f. outcrops of 1 and — g. Falls. — h. h. h. Bluff of middle cretaceous Shales and Sandstones facing Aspen Creek. — i. i. i. Trachyte intruded among the Shales — n. Anthracite Creek near the Mouth of which is the seam of anthracite Coal. — The Creek cut into Treasury Mt. at c and d. and pass out at the Falls g.

FIG. 8.—CASCADE ON ROCK CREEK, COLORADO.

Mountain. The dip is at first slight, but before we reach the Lower Cretaceous, it rises to 30°. The strike is at right angles to the stream-course, but turns to the south on both sides of the mountain. It appears, from such examinations as I was able to make, that Treasury Mountain is a short anticlinal, or oval shaped quaquaversal, that seems to have been produced by some agent associated with great heat, since the high degree of metamorphism of the entire series up to the Middle Cretaceous is quite remarkable. I doubt if the sedimentary measures are entirely penetrated in any part of the mountain. The Jurassic and Lower Cretaceous rocks reach high up the sides of the arch, while the lines of shale-outcrop are ranged around and support the base. The dip is toward Rock Creek on the east and north, and toward two of its tributaries on the south and west. The only place where the Paleozoic rocks have been penetrated and exposed is on the east side, where the two branches of Rock Creek, leaving the Cretaceous synclinal, cut directly into the side of the anticlinal, passing through the Cretaceous, Jurassic, and Upper Carboniferous rocks, into the Lower Carboniferous, (see Figure 7;) here, in a deep, narrow cañon, they unite, and turning to the right the resultant stream follows for some distance along the strike until it reaches the north end of the oval, where it cuts its way out again into the broad depression eroded from the Cretaceous shales. In passing out over the highly metamorphosed beds of the Dakota group, a splendid cascade is formed with a fall of 500 or 600 feet. The sandstones of this group are so greatly changed here that it would be impossible to recognize them outside of their relations to the overlying strata. They are reduced to a very hard flinty quartzite, greenish in color and nearly uniform throughout. The shales above are much hardened, and the Jurassic and other substrata are so consolidated as to be but a series of flinty quartzites. For the sake of comparison I present in this connection, Fig. 9, two sections of the Cretaceous rocks, one made in this locality and the other on the border of the plains. The Dakota group is everwhere the same. The series of shales are almost identical, and the transitions from shales to the sandstones above are as like as possible. Palm-leaves and fucoids are found in the lower part of these sandstones and in corresponding horizons.

In the east the lignitic coal is found near the base of the sandstones, while the anthracite coal of the West occurs 2,000feet higher. An analysis of this coal, made by Professor Mallett, demonstrates the fact that it is of fine quality. (See chapter IX, Dr. Peale's Report.) The seam is about four feet thick, but the locality is one most difficult of access as well as remote from any probable market. It certainly cannot be utilized for many years yet unless the immediate region should prove rich in mines, in which case it would be invaluable for smelting purposes.

Between Treasury Mountain and the Snow Mass group there is a long, narrow Cretaceous valley, produced by an abrupt synclinal fold, in which the strata are doubled back upon each other. The forces have so predominated on the east side that the beds on that side are pushed beyond the vertical and lie atop of the gently inclined strata of the west side. The Upper Cretaceous sandstones do not occur in this depression south of Aspen Creek; we have, therefore, a double thickness of the black shales in the middle of the valley, giving in all a thickness of nearly 4,000 feet. The shales are followed or supported on either side by the older strata, in the usual order. The depression produced by this fold may be followed the whole length of the Elk range, and separates it from the West Elk group, producing northern and southern systems of drainage.

THE GREAT FAULT FOLD OF THE ELK RANGE.

On September 5th we reached the northern limit of our last year's work, and little remained to be done but to examine a few complicated spots along the main fold of the Elk range. Most of the difficult problems occur along this fold, between station 24 on the north and Cascade Creek on the south, and as the axis of the fold is west of the crest of the range, the complicated parts are cut by the deep transverse valleys of the western slope and many good sections are exposed. Six of these, D, E, F, G, H, and I, are given in the main sheet of sections accompanying the map.

It will be observed by reference to the map that the granite, which is represented by heavy horizontal lines and marked A A, occurs in two great masses, and that in these masses are the culminating summits of the range. The northern, which is cut by sections D and E, is the Snow Mass group, and the southern, cut by sections G, H, and I, is the White Rock group. At first glance it might seem that these were separate centers of elevation or upheaval, or at least that they were not intimately related, but closer examination develops the fact that there is a line of disturbance of a very marked and extraordinary character connecting them. Section F cuts this fold at *e e*, and gives one of its peculiar phases. But I found that a very large number of sections, even, could not be made to give a connected idea of so complex a fold. I have, therefore, prepared the accompanying illustration (Fig. 11), in which the entire fold is given in relief and so placed upon an outline map that the location of the various parts may be easily recognized. I have carefully kept in view the idea of showing simply the peculiar foldings of the broken edges of the strata. The granite areas have been shaded down and the effects of erosion partially ignored in order to develop the one idea, and a single convenient horizon, the base of the Cretaceous, is taken, entirely disincumbered, for the sake of greater simplicity.

It should be remembered that this representation is highly artificial; that in reality the fold is very obscure, and has but little apparent effect upon the topography; that it is cut into fragments by ten immense valleys; and that its anatomy can only be studied on the steep faces of the ridges between these valleys.

It will be seen by reference to the figure and the sections opposite, that the conditions all along the east side are simple, there being a gradual and gentle dip from the crest of the range toward the valley of Roaring Fork, while on the west side there has been a general depression or downthrow, so to speak, amounting in many places to 7,000 or 8,000 feet; at the same time a combination of movements, principally lateral, have produced along the axis an immense wrinkle, a fold so abrupt that the beds are crushed and shattered and the severed edges shoved past each other, as shown in the drawing and sections between *e* and *n*. It will not be difficult to imagine that while this was going on, the plastic mass beneath was assisting the movements and shaping the results, and that during the process it forced itself, or was forced, through the fractured line in the two great masses of the Snow Mass and White Rock groups.

Beginning at the north, I shall give a detailed description. All along the north face of the Snow Mass group the sedimentary rocks lie in the usual order upon the granites, with a slight dip toward the north. (See axis-section, large sheet.) Between Station 24 and Aspen Creek the granite begins to fault up past the broken edges of the sedimentary

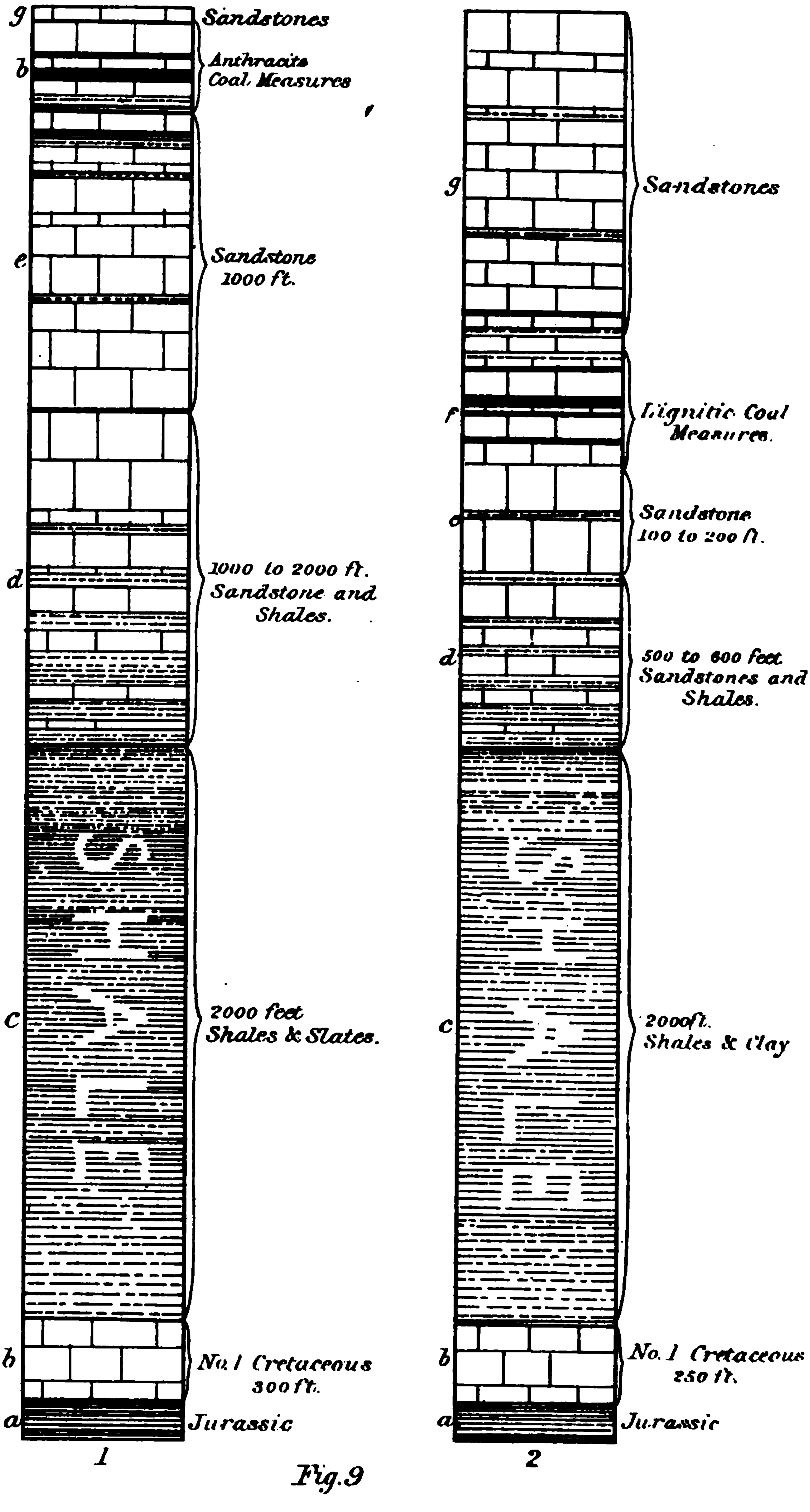

Fig. 9

Relations of the Coal Beds to No. 1 Cretaceous.
Section 1, West of the Range, Elk Mts.
Section 2, East of the Range, – Cache la Poudre, or Cañon City.

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strata, and at Aspen Creek, as previously mentioned, only the Upper Cretaceous remains in view, with a fragment of primordial rock at *a* in the deepest part of the valley. South of Aspen Creek for a few miles the whole series seems to be depressed beneath the surface, while the granite peaks on the east side of the fault-line rise to the height of 3,000 feet, making a total displacement of at least 11,000 feet. South of *b* there is a high, sharp ridge formed of a series of almost vertical Carboniferous rocks, which seem to have been carried up by the granite, or at least to have been left in the present position by the dragging of the fault. In the south end of this ridge the dip increases from 90 to 135 degrees, that is, 45 degrees beyond the vertical, and nearly the whole series of sedimentary rocks appear in this position in the side of the cañon at *c*.

In the triangular spur between *c* and *d*, a large mass has been carried back 90 degrees past the vertical, so that the Silurian quartzites occupy the top of the ridge, and the Cretaceous rocks the bottom of the valley.

The fold has been so sharp at *e* that the beds have been broken off, and the continued upward movement of the granite has bent the broken edges up, producing a synclinal in the inverted strata.

In this place the belt of granite is quite narrow, so that the relative positions of the strata on opposite sides can be studied with ease.

The Silurian rocks of the east side outcrop on the summit of the water-shed of the range at *f* 2,000 feet above the creek, and since the Middle Cretaceous rocks of the west side are depressed to an unknown depth beneath the creek-bed, we can safely say that there is a vertical displacement of at least 8,000 feet.

The amount of lateral movement (at right angles to the axis of the fault) may be expressed by the difference between the width of the granite belt *e f* and that of the inverted fragment *d e*, and will hardly fall short of 6,000 feet.

South of *e* the beds gradually rise again from the inverted position, and a high, narrow ridge is formed of the almost vertical Carboniferous rocks. This ridge is not above four miles in length, and is connected with the main range by an irregular cross-ridge that separates the head-waters of the north and south branches of Rock Creek. The tongue of granite that extends southward from Snow Mass along the fault-line is obscured before reaching this cross-ridge by the overlapping sedimentary rocks (at *h*). Here the greatest confusion occurs, and large masses of the rocks, of all ages, are found in the most unheard-of relations to each other. The strata of the west side have been depressed and caught beneath the encroaching strata of the east side, and are folded back upon themselves, as seen in the drawing, Figure 11. This peculiar and somewhat irregular fold may be traced for a distance of six or seven miles, and in this distance is cut at right angles by three immense valleys. The sections exposed in the faces of these are not always distinct, but at the same time make it possible to study the peculiar anatomy of the fold. I observe that in every place where there is an exposure the Carboniferous rocks of the east side rest upon the upper surfaces of the hard sandstones of the Dakota group, and with such a degree of regularity that I was for a long time in doubt as to the identity of the latter. In studying the section exposed on the north side of the valley which crosses the fault at *i*, I began near the crest of the main range west of Maroon Mountain, and passed down through nearly 3,000 feet of Carboniferous sandstones, limestones, and conglomerates (which have a gentle dip to the east and undoubtedly belong to the eastern side of the

range), but on the slope between *h* and *i*, I came suddenly upon the well-known sandstone of No. 1 Cretaceous, lying beneath the Paleozoic rocks and to all appearances conformable with them. Keeping on at right angles to the dip, I passed first over the outcropping edges of Jurassic and Triassic (?) rocks; then over a ridge of Carboniferous conglomerates and limestones, much crushed and metamorphosed; and finally, beneath these still, over a full but much distorted series of Triassic, Jurassic, and Cretaceous rocks. The dip rises in places to 70 and 80 degrees, and the strikes are not quite uniform. I was at first entirely unable to account for this extraordinary succession of strata, and did not succeed in solving the problem until I had followed the outcrops across the valley to the south and discovered in the higher ridge at *j* the arch of the fold, which, on the opposite side of the valley, had been carried away.

It seems that in the first place a great fault occurred, in which there was a throw sufficient to place the Lower Cretaceous of the west side opposite the Lower Carboniferous of the east side, and that a powerful lateral movement had then driven the opposing strata together, the harder Carboniferous rocks sliding forward upon the upper surface of the quartzites of the Dakota group, and at the same time bending them and portions of the firmer substrata back in a sharp fold, which, from the continued pressure, has been carried *en masse* beyond the vertical and almost severed below by the immense pressure. (See section F, large sheet.) In the next ridge south, at *j*, the fold is not so abrupt, and the ridge *m*, facing White Rock Creek, there is only a gentle arch of the strata (see section G, large sheet), while a considerable gap occurs between the faulted strata in which the granite appears.

At *n* the infolding ceases, and in the valley at *o* the strata dip some forty degrees to the west (section H, large sheet). Toward *p* they rise again to the vertical, and at *q* have been pushed back to forty-five degrees past the vertical by a mass of granite, which now lies superimposed upon the ridges like so much trachyte.

Before reaching the bed of Teocalli Creek at *r*, the strata fall back again almost to the normal horizontal position.

Here the fault forks; one branch extends southward through *s*, and the other turns eastward along the north face of Teocalli Mountain and continues in a pretty direct course to station 3.

The elevation on the north side of this branch of the fault has been very great, and has extended over a large area. White Rock and Amphitheater Mountains have probably been the highest granitic points, but the whole mass of the Castle group has been carried up so uniformly that the Paleozoic rocks lie in an almost horizontal position upon a plateau-like mass of granite. (See section H, large sheet.)

A few miles south of station 3, which is the most southeasterly granite outcrop of the Castle group, a small pyramidal mass of granite has forced its way up through the primordial rocks bordering the granites of the Sawatch range, producing the summit of Italian peak. Although this bit of granite seems quite isolated from the previously-described centers of disturbance, a very marked line of fracture and faulting may be traced between it and the Castle group, but as the details of this region have already been given by Drs. Hayden and Peale, I shall content myself by giving, in conclusion, a brief recapitulation of the more striking features of the Elk range. Topographically speaking, it is a spur of the great continental divide, but geologically it is quite independent in origin. It trends nearly northwest and southeast, so that one extremity lies high upon the slopes of the Sawatch range, while the other extends far out into the low country bordering the Grand River.

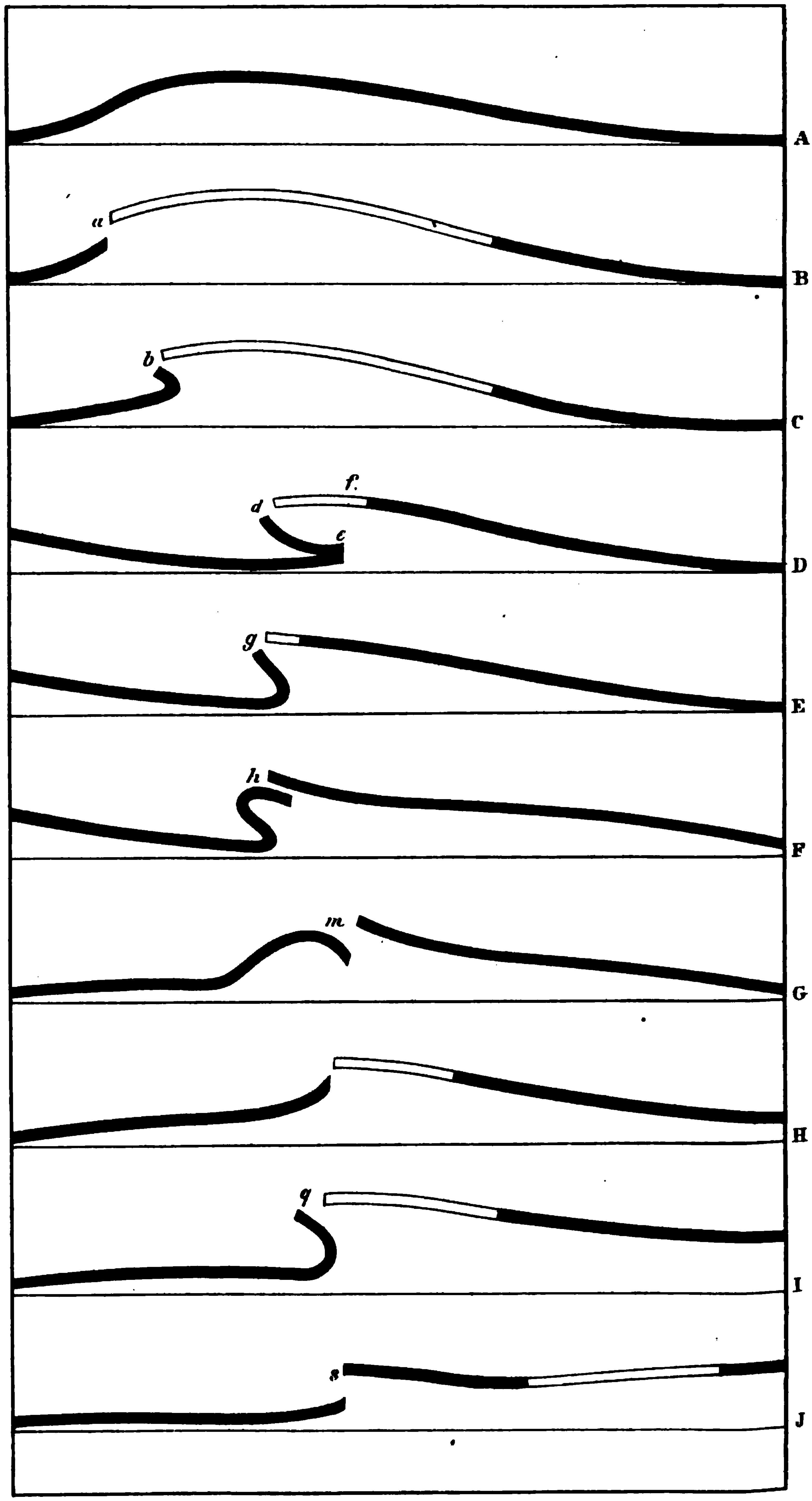

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Fig. 10.

FIG. 11. PART OF THE GREAT FAULT FOLD OF THE ELK MOUNTAINS.

It seems to owe its present conformation to the occurrence of three nearly parallel lines or belts of displacement, two of depression and one of elevation.

The depression along the valley of Roaring Fork, which has already been presented in Fig. 1, is included between the diverging axes of the two ranges, and exhibits some very curious examples of faulting and folding.

The elevated belt, which constitutes the range, is about forty miles in length. It slopes gently toward the depression on the east, but drops off very abruptly on the west in a great fault-fold. Four considerable areas of eruptive granite occur along the axis of this belt or zone, and the depressions between these contain synclinal folds of the sedimentary beds, as seen in the longitudinal section given on the large sheet.

It will be noticed, by reference to the transverse sections, that the axis section, which follows approximately the crests of the range, is generally to the east of the axis of displacement. The reason of this will be plain, when it is observed that the entire series of strata rise gradually from the valley of the Roaring Fork synclinal, until the axis of displacement is reached, and that the highest points, which would at first stand along the line of this axis, are now carried back by erosion from one to five miles to the east.

The amount of vertical displacement along the fault-fold, between Aspen Creek on the northwest, and station 3 on the southeast, does not fall short of 5,000 feet at any point, and will probably measure 10,000 feet in one or two places along the west side of the Snow Mass group.

The depressed belt west of the range, occupied by the valleys of Rock Creek and East River, is very intimately associated with the fault-fold, and has been produced by the downthrow on that side rather than by any independent folding, as the strata do not rise at all to the west, except for a few miles along the east face of Treasury Mountain, as seen in sections E and F.

On the 11th day of September we fell in with the main party just south of Italien Mountain, and after spending a few days in the review of the geology about the headwaters of East River, began our return march to the East.

REPORT OF A. C. PEALE, M. D.,

GEOLOGIST OF MIDDLE DIVISION.

1874.

REPORT OF A. C. PEALE, M. D., GEOLOGIST OF THE MIDDLE DIVISION.

WASHINGTON, D. C., *May* 15, 1875.

SIR: I have the honor herewith to submit my report as geologist of the middle division of the United States Geological and Geographical Survey of the Territories for the season of 1874.

The report of Mr. Henry Gannett, who was in charge of the division, will supplement this report, and to it I refer for more detailed information in regard to the routes followed, elevation, and topographical features of the district assigned us. We left Denver on the 21st of July, and by the 5th of August had commenced work near the head of the Eagle River.

On the 1st of November work was suspended and we started for Denver, reaching that city about the middle of the month. During the three months we were in the field at work 5,300 square miles were surveyed.

My plan of working was in general the same as during the season of 1873.

Accompanying the topographer in charge to almost all the high stations, I made sketches of the surrounding country, on which I defined in colors the boundaries of the various formations. Whenever time permitted I made detailed sections of the strata.

This report is divided into nine chapters, the first three of which are devoted to the general geological and topographical features respectively of the valleys of Eagle, Grand, and Gunnison Rivers. The succeeding chapters give the special and detailed features of the various formations, and the economical geology of the district. Catalogues of the minerals and rocks are appended.

The report is accompanied by maps and sections, for which I am largely indebted to Mr. William H. Holmes and Mr. Henry Gannett. I have colored the geological formations on a provisional map, reduced by photography from the original drawing of Mr. Gannett's map of the district.

The rapidity of preparation and necessary absence during publication of the report must be my excuse for any errors that may appear.

In conclusion I wish to express my thanks for the cordial co-operation of all the members of the party.

With great respect, I remain your obedient servant,

A. C. PEALE.

Dr. F. V. HAYDEN,
United States Gologist.

CONVENTIONAL SIGNS USED IN PLATES

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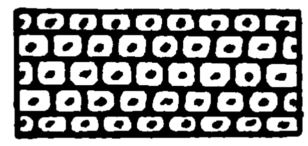
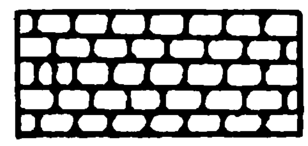
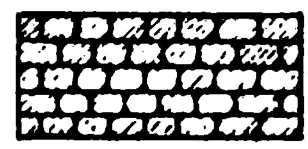
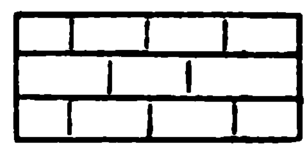
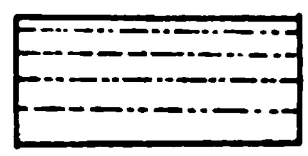
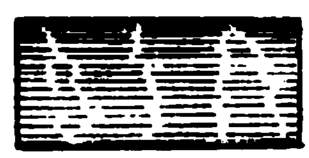
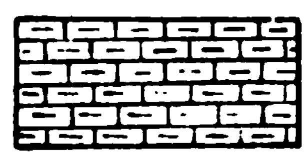
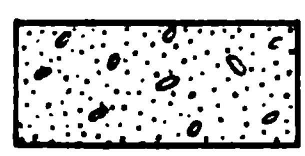
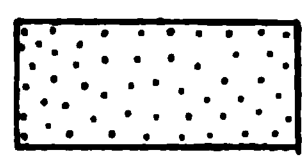
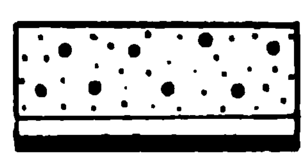
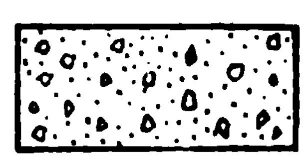
Quartzites	
Light colored sandstones	
Red sandstones	
Gypsiferous shales	
Light shales	
Dark shales	
Limestones	
Alluvium	
Porphyritic trachyte	
Rhyolite, tufa, & obsidian	
Breccia	
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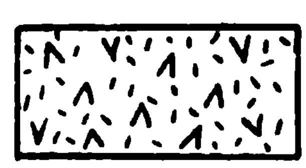
Archaean	

INTRODUCTION.

The territory assigned to the middle division for the season of 1873 was thus outlined in the letter of instruction given to Mr. Gannett, who was in charge, on taking the field:

"The boundaries of the area to be mapped by your division (or as much of it as the season will allow) are as follows: Commencing at the intersection of meridian 109° 30′ and the Grand River, the line runs northeastward up the Grand River to the junction of the Eagle River; thence up the Eagle River to the mouth of Roche Moutonnée Creek; thence westward along the northern boundary of last summer's (1873) work to its intersection with meridian 107°; thence southward along the western side of last summer's work, approximately on the 107th meridian, to parallel 38° 30′; thence westward on this parallel to the intersection of meridian 109° 30′; and thence northward on this meridian to the intersection of 109° 30′ with Grand River."

This area has an irregular boundary, Grand River, on the north, and includes between 7,000 and 8,000 square miles, of which about 5,300 square miles were actually worked during the season. The area is bounded on the west by the Uncompahgre and Gunnison Rivers, leaving the area west of these streams for another season. This gave us a well-defined natural boundary as our western limit. The greater portion of the area is plateau country, the elevation of which ranges from 9,000 feet to 11,000 feet above sea level. The mountainous portion is limited to the southeastern part, along the western edge of the Elk Mountains. The drainage is comprehended in two systems, viz, that of the Grand River and that of the Gunnison River.

The entire district is within the limits of the reservation for the Ute Indians, and a large portion of it had never been visited by white men.

In 1853 Captain Gunnison, exploring for a route for a Pacific Railroad, surveyed a belt of country along the river that now bears his name. In the winter of 1853–'54, Col. John C. Frémont passed over nearly the same route that Gunnison did. In 1845 Frémont followed the Arkansas to its head, crossed Tennessee Pass (called Utah Pass by him), to the Piney (Eagle), and followed it for some distance, finally crossing to the Blue (Grand River), and continuing westward. In 1873 Lieutenant Ruffner followed Ohio Creek to its head, crossed to the head of Anthracite Creek, and thence to Slate River, going eastward to the Arkansas.

All these were merely reconnaissance surveys, and added but little to our knowledge of the country outside of their routes. The great mass of country lying between was unexplored.

The general geological features of the district will be given in subsequent chapters. The greater portion of the district is covered with rocks of Tertiary and Cretaceous age, covered in places with lava-flows.

Mr. Gannett's report will give all details in regard to the elevations of peaks and passes, and topography of the country.

CHAPTER I.

SURFACE GEOLOGY—VALLEY OF EAGLE RIVER.

Eagle River is a branch of Grand River, one of the forks uniting to form the Colorado. It rises immediately opposite the head of the Arkansas, and is about sixty-four miles in length. At its head it is formed by two main branches, one having its source in the Park range, and the other rising in the Sawatch range, which terminates in the Mountain of the Holy Cross. The Sawatch range, on the western side of the valley of the Arkansas River, forms the continental divide. North of the Holy Cross the range falls off, the water-shed or divide crossing to the eastward at Tennessee Pass, between the heads of Eagle River and the Arkansas.

Eagle River flows around the northern end of the Sawatch range. Its general course, at first, is a little west of north. Ten miles north of the Holy Cross it bends more to the westward, and the general course for nearly fourteen miles is north 64° west. It then turns abruptly and flows south 78° west, which course it holds quite uniformly for about twenty miles, to its mouth.

The greater part of its drainage is from the south. The entire area drained by the southern branches is a little over five hundred square miles. The opposite side of the river was in Mr. Marvine's district, and will no doubt be fully treated of in his report.

The river is a very rapid stream throughout its entire length. The average fall is 67.2 feet per mile. From Tennessee Pass to the mouth of Roche-Moutonnée Creek, the rate is 150 feet, and from here to the head of the second cañon 49.4 feet, while from the latter place to the mouth it is 32.4 feet.

The upper part of Eagle River was partially described in the last annual report (1873), our division having followed it as far as Roche-Moutonnée Creek, for the purpose of ascending the Mountain of the Holy Cross. In order that this report may be complete I will have to repeat a portion of the notes on my work of the previous year. For a distance of about three miles from Tennessee Pass the river is in a cañon-like valley, the hills on either side being comparatively low and rounded. The rocks are granitic, with occasional dikes of volcanic material. From this cañon the stream emerges into a broad meadow-like valley of about four miles in length, in which it is joined by the branch rising in the Park range near Quandary peak.

The valley is three miles in width, the hills on either side of granitic rock being capped with sedimentary formations, which will be referred to in more detail in another part of the report. Leaving this valley, the river flows immediately into a cañon with steep sides, the trail leaving and crossing to the western branch. A line of outcrop of quartzites crosses the river and follows the summit of the ridge between the two branches. These beds are, in all probability, primordial. Carboniferous beds outcrop on the eastern side of the eastern branch, but I defer their description for the present.

The western branch is in reality the continuation of the main river, being twelve miles long. It rises in the Sawatch range, and drains the country for six miles south of the Mountain of the Holy Cross. Its course at first is north 40° east, but in the lower two miles it flows almost at right angles to this, being parallel to the eastern branch. On the western side of the stream the hills are gneissic, the sedimentary capping have been removed by erosion. All the streams joining the river above the mouth of the Piney on the south and west present abundant evidence of intense glacial action. They are parallel to each other, the general course being north 40° east. The glaciation was described in the report for 1873, and I, therefore, simply refer to it here.

Before uniting with the western branch, the eastern fork is joined by a branch of considerable size having its source in the Park range, opposite Ten-Mile Creek, one of the tributaries of Blue River. The geology about the head of this stream has never as yet been fully investigated, but I am inclined to think that all the formations, from the Carboniferous to the Red Beds, inclusive, will be found along its course. The Cretaceous beds would scarcely appear until we reach a point farther north, near Mount Powell. As I mentioned in last year's report,* I think it probable that a fault extends along the western edge of the Park range, west of Blue River.

After the union of the two forks, Eagle River enters a deep and inaccessible cañon of about four miles in length, cut in dark-colored gneissic rocks, from which it emerges just above the mouth of Roche-Moutonnée Creek. The trail keeps high (800 to 1,000 feet) above the level of the river, on the hills on the eastern side, near the edge of the sedimentary formations, which are exposed on both sides of the cañon. On the western side there are only patches of quartzite, remnants of the Potsdam group. On the eastern side there are other beds, probably of Silurian age, upon which rest Carboniferous layers, and possibly the Devonian, although it seems to be altogether wanting, there being no positive evidence of its existence here. These beds all dip about 10° to 20° to the northeast, the inclination gradually changing more to the north as we follow the river. In the bluffs on the right-hand side of the river, opposite the mouth of Roche-Moutonnée Creek, formations from those of Primordial age to the Permian, or Permo-Carboniferous, are exposed. This, of course, includes the Devonian doubtfully, for that formation has not, as yet, been positively identified in Colorado. Just above the mouth of the creek gneiss is seen on the edge of the river, but as we go down, higher and higher sedimentary beds gradually form the base of the bluffs, and below the Piney the line of outcrop of the Carboniferous crosses, and still farther down even the Cretaceous shows on both sides, the strike curving around the end of the range and continuing along the western side to the Elk Mountains, in our last year's district. On the west side of the river, as far as the Piney, there are long spurs, or ridges, sloping gently at an angle of about 10°, toward the river. These ridges are capped with quartzite, which I have considered to be the equivalent of the Potsdam group. These quartzites terminate within a short distance of the center of the range. Erosion has removed the beds formerly resting upon them, their hardness preserving them. They are shown in Section B, Plate I.

The creeks, separating these ridges, have their origin in beautiful meadow-like parks, nestling immediately below the peaks in the range, from whose snow banks they derive their supply of water; thence they flow with a comparatively uniform descent to within a short distance of

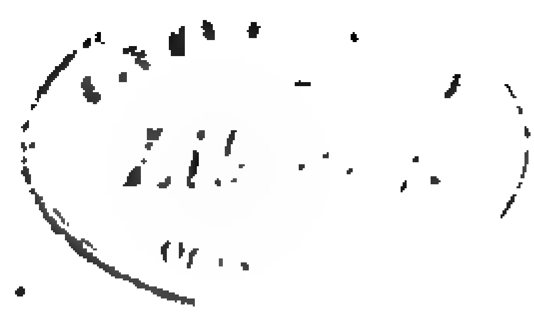
*Seventh Annual Report, 1873, page 242.

Plate I.

A d e B

Fig 1. Section A. 11½ Miles.

Fig 2. Section B.



Eagle, when they descend rapidly to its level. The erosion along the main stream has been much greater for several reasons. In the first place the beds have a dip from the main range, leaving, perhaps, a sort of trough between the Sawatch range and the Park range.. This determined the course of the river, which we accordingly find curving around the range as the sedimentary formations do. These beds are also in a great measure made up of sandstones that are comparatively soft, and yielded readily to the action of water. The river, therefore, is in a monoclinal rift for a considerable portion of its course.

In the cañon, above the mouth of Roche-Moutonnée Creek, the streams reach the river by falls and cascades.

The slopes are heavily timbered with dense pine forests, and along the streams are groves of cottonwood, (*Populus tremuloides.*) In the cañon are huge bowlders, which, mingled with the dead and fallen timber where the forest has been swept by fires, cause great difficulty in traveling.

At the mouth of the Piney, a stream coming in from the east, the river again enters a cañon. It is something over a mile in length. At the head of the cañon is a high bluff on the right side, while the opposite bank is broken down, allowing the passage of the trail over the hill, not very far above the level of the water.

On the south side, on the top of the quartzite, (Potsdam?) are limestones, and, a short distance below, the Carboniferous sandstones cross the river, the angle of inclination being about 25°, a little more to the northward than in the bluffs opposite Roche-Moutonnée Creek.

Below the cañon the Eagle enters a broad valley, extending for ten miles, to the head of another cañon. This valley will probably average a mile in width, and is filled with the *debris* washed from the hills on either side. It is terraced and covered with a growth of sage-brush, (*Artemisia.*) Bordering the river is a narrow belt of alluvium which widens in the lower part of the valley around two small lake-expansions of the stream. There are beautiful meadows around the lakes. The lower lake is about a mile long and an eighth of a mile wide, while the upper one is much smaller, being only a little over a half a mile in length.

Here we found a party of men camped. They were prospecting and fishing. Eagle River abounds in delicious trout of a large size, some that we measured being sixteen inches in length. Their plan was to take the fish every week to Oro City, on the Arkansas River, and sell them. They also claimed to have found gold in some of the streams coming from the Sawatch range. The gold, if present, is probably derived from the granitic and gneissic rocks that prevail near the heads of the creeks.

The course of the Eagle through the valley we have just described is north 78° west. On the southwest side, the long sloping spurs that we noticed above the Piney still continue. Near the river they are lower, and, for the most part, grassed over, only an occasional outcrop of limestone or sandstone appearing. On the opposite side are outcrops of red sandstone (Triassic?). I have referred to the cañon which bounds the lower end of the valley. It is somewhat curious. On entering it the river changes its course and flows north 45° west, which direction it keeps for four miles. It then turns abruptly and flows south 72° west. This portion of its course in the cañon is three miles in length. On the south side is a semicircular ridge, extending from the head of the cañon to its foot. It reminds one of a bow, while the river, with its bend, is the cord ready drawn to discharge the arrow. We made two stations on

this ridge, which is 1,500 to 2,000 feet above the river. Its rim is of the sandstone of No. 1 Cretaceous (Dakota group), which c the river at the head of the cañon, almost at right angles to its c the dip being in the direction of the stream. On the north side is a curious spoon-like curve in the strata, shown in Plate II, whic be fully explained in Mr. Marvine's report, as it is in his district. neath the Cretaceous sandstone, in place, are the Jurassic shale limestones, followed by the Red Beds, (Triassic?) underneath wh a series of gypsiferous beds, exposed on both sides of the river. will all be referred to again when I come to speak of the vario mations separately.

The river, on leaving the cañon, keeps the course it has there it reaches the Grand. The valley is about twelve miles long, exte to within five or six miles of the Grand. It is wide and bordere low hills of gypsiferous shales, covered with a growth of cedar (*Jun occidentalis*). Beyond these hills are higher ones, not reaching timber-line, the basis being red sandstones. The gypsum hills ar spicuous from their white color and their softness, which causes th yield readily to eroding influences. They are therefore muc up by gullies which for the greater portion of the year are dry, but d storms are the beds of torrents washing down the soft clay. Each extending into them, fans out into a great number of small gullies. shales and sandstones of which they are formed belong to the same zon, viz, Carboniferous or Permo-Carboniferous, as do those men as occurring below the Red Beds above the cañon.

It seems as though the Eagle, instead of entering the cañon and c its way across the hard sandstone of the Dakota group, should worn its channel through these softer beds that lie to the southw its present course. It might perhaps have done this, but that an of eruptive rock (basalt), of great hardness, caps the hills south cañon (see map A), forming a barrier that in all probability deter its deflection to the northward. Fig. 1, Plate II, represents a s across this area from the Eagle to creek *g*.

There are two large creeks flowing into the Eagle from the so this lower valley. The first or eastern one I will designate as cr and the other as creek *h*. They both have their origin in a broad-t ridge of red sandstone (Triassic?) which forms the divide or wate between Frying-Pan Creek, a tributary of Roaring Fork, and the of the Eagle. In 1873 we made a station (No. 82), on this ridg from it I made a section,* showing the structure of the country as peared to be looking northward. I said, in the report,† that seemed to be a series of faults and that the section might have modified when the region should have been more closely studied.

I found this year that the beds I then thought to be Cretaceous, ing from the color as seen from the station on looking north, are the gypsiferous beds that lie beneath the red sandstones. Instea number of faults, therefore, as shown in the illustration (Fig. 3, 19, Report for 1873), there is simply an exposure of the gypsum b both the places marked "Cretaceous," at the head of creek *h* and i valley of Eagle River. As I mentioned in my notes of last yea red sandstones on station 82 dip a few degrees west of north, incl at a comparatively small angle, which increases as we go northw On station 8, the dip is in the same direction, as also on station 9.

* Plate 19, Fig. 3, 7th Annual Report, 1873.
† Page 266, 7th Annual Report, 1873.

low bluff-like wall, ten to twenty feet above the level of the water. It seems to have come down the ravines in the hills bordering the valley, and to have spread out like the slag from a furnace. The river seems to have stopped its progress, for no trace of the rock could be found on the south side. It seems to have forced the river to the southern side of the valley, and the force of the water has scooped out the hills, leaving bluffs on that side in which the strata forming the hills are beautifully shown.

N. PETERS, PHOTO-LITHOGRAPHER, WASHINGTON, D. C.

CHAPTER II.

SURFACE GEOLOGY—GRAND RIVER AND ITS TRIBUTARIES.

Grand River rises in Grand Lake, in the northeast corner of Middle Park, west of Long's Peak, and derives its supply of water near its head from the Colorado or Front Range, the divide between Middle and North Parks and the Park range.

It unites with the Green River to form the Colorado, and has a total length of about three hundred and fifty miles, of which one hundred and fifteen miles is in our district. It rises farther eastward than any other water in Colorado which flows into the Pacific.

On some maps the name Blue River is given to it, while the name Grand is applied to the Gunnison and to the Grand proper below the mouth of the Gunnison. Gunnison* calls it Nah-un-kah-rea or Blue River, and the Gunnison he names the Grand. Blue River, in reality, is in Middle Park and a branch of the Grand.

The reasons for using the name Grand in preference to Blue are briefly as follows:

It is really the main stream, being, at the junction of the Gunnison, twice the size of the latter, and if the name is given to the lower portion it should also be given to the largest stream above. Again, it is so known all through Colorado and at its head in Middle Park, and will probably, therefore, always hold good, while the name Blue is restricted to the branch rising in the divide between the Middle Park and the South Park, and flowing northward along the eastern side of the Park range.

In Middle Park Grand River is from forty to fifty miles in length, and has been fully described by Mr. Marvine in his report for 1873, and from the Park range to the mouth of Eagle River, a distance of about forty-five miles in a straight line, it lies within his district for 1874, and will no doubt be fully reported on by him.

From the mouth of the Eagle to the mouth of the Gunnison, it formed the boundary between the northern and middle districts, and we have therefore to treat here only of the general features and geology of its southern drainage in this part of its course. There are three large branches which I will take up in their order, commencing at the mouth of the Eagle.

On glancing at the map we notice that there are two general courses for the streams, the Grand flowing south of west and turning more and more to the southward as we go west, until at one point it flows almost due south, afterward turning to the west before reaching the mouth of the Gunnison. The courses of the main branches, especially of the first two, are west of north. The third holds the same general course at first, but are afterward modified by circumstances that will be explained farther on.

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*Pacific Railroad Report, vol. ii.

The area drained by these branches includes about 1,300 square miles.

The country included is generally plateau-like in character. This is more apparent to the westward, and in the divide between the Grand River and the North Fork of the Gunnison. The general elevation of the plateau is from 9,000 feet to 11,000 feet.

In the eastern portion, from the Eagle River to a short distance west of Roaring Fork, are rolling hills covered with scrub-oak (*Quercus alba*), cotton-woods (*Populus tremuloides*), and stunted cedars (*Juniperus occidentalis*). The latter was most abundant on the lower slopes, and seemed to thrive best on soil derived from the breaking down of the shales in the upper part of the Cretaceous and Tertiary formations. The rocks throughout this region were mostly of Tertiary age, capped in places by basalt. The general geology, however, will be dwelt on as we proceed.

The course of the Grand, from the mouth of the Eagle to the mouth of Roaring Fork, is south 60° west. Most of this distance, sixteen miles in an air-line, the river is in cañon, the head of which is a little over three miles below the Eagle. It is probably impassable to travel, the sides being very steep. There is no Indian trail following the course of the river. Mr. Marvine's party kept on the hills some distance back from the edge on the northern side, and we followed an Indian trail across the hills to a stream which joins the Grand at the head of the cañon. This trail seemed to be much used and leads across to Roaring Fork, which it strikes above the mouth of Rock Creek, a branch rising in the Elk Mountains.

The valley above the cañon is about three and a half miles in length, and although wider than the valley of the Eagle just above its mouth, is still comparatively narrow. On the north side are limestone slopes, and on the south low, rounded hills of the gypsiferous beds. At the head of the cañon and forming the gateway, as it were, are beds of massive limestone, probably of Carboniferous age. They dip to the northeast, inclining about 20°. Farther along in the cañon there may be outcrops of older beds, which can be determined only by following the bluffs close to the river. The hills on the south side of the cañon are capped with a black vesicular basalt, which rests immediately on the Triassic red sandstones. The dip of these beds I was unable to determine, but they are probably conformable to the layers beneath.

The creek up which the trail led, after leaving the Grand, joins the river by cutting a small cañon through limestones similar to those at the head of the cañon of the Grand. These beds are somewhat massive, and above them are blue limestones with interlaminated sandstones passing into gray and white sandstones, with yellow and black shaly beds above. These are beneath the pink gypsiferous beds outcropping farther up and corresponding with those on Eagle River. Still farther up stream the Red Beds appear, the line of outcrop crossing the creek near its head.

Leaving this creek, we crossed to the waters of Roaring Fork, the first stream reached being a branch joining it about two miles below the mouth of Rock Creek. The country between the Grand and Roaring Fork here is a rolling plateau covered mostly with a growth of scrub-oak. The plateau is capped with a black vesicular basalt, which in places is worn away, exposing the red sandstone beneath. The head of the creek is in cañon in which the Cretaceous beds are shown, dipping to the southwest. Station No. 11 was almost on the line between the top of the Red Beds and the overlying stata. Farther down

the creek there are exposures of Cretaceous beds in patches, whose relations I was unable to determine definitely.

Between the head of the creek and Frying-Pan Creek is a broad-topped hill or mesa, capped with black vesicular basalt. I referred to this mesa last year,* and then supposed the capping to be trachytic. The beds beneath it, outcropping on the south and southeast sides, are almost horizontal, the sandstone of the Dakota group (Cretaceous No. 1) appearing on top, the Jurassic beds and Triassic sandstones lying beneath in their order. A short distance farther north, on Frying-Pan Creek, the dip of the red sandstones, which outcrop in massive beds, is a little east of north at a very slight angle, 5° to 10°. As we have already seen, the Cretaceous formations on station 11 dip southwest. The head of the creek that we are describing, probably has its origin in a synclinal depression, which deepens to the northwest in going down the creek, and gradually dies out beyond its head on the broad-topped hills north of Frying-Pan. The folds in this region are generally very gentle, but their axes run in almost every direction. There is so much eruptive material on top of the sedimentary beds that it is difficult to trace the connections between the different outcrops. Mr. Marvine thinks there is a fault running beneath the plateau, between the Grand and Roaring Fork.

Scattered along the course of the creek, and its branches rising in the plateau, are numerous little meadows. The lower seven miles of its course the creek is in cañon, which deepens rapidly as we go down. The rocks at the head are basaltic, capping the bluffs on either side. They are present on the hills, or rather plateau, throughout the length of the cañon. At one point I think Cretaceous shows, although I cannot be certain, as I did not have time to visit the outcrop. Farther down, the Red Beds show, and beneath them, at the mouth of the creek, there is a considerable thickness of the gypsiferous series.

I will take up next the valley of Roaring Fork. The upper portion of the valley was described in last year's report, so that this year we have to do only with the lower part of its course, that below the mouth of Frying-Pan Creek. There is one point, however, that I wish to refer to here. When speaking† of the small butte between Maroon Creek and Roaring Fork, I was at a loss to account for the inversion of the beds exposed in the butte of which I gave a section. This year the Elk Mountain region was studied in more detail and a great many obscure points were explained. In the case mentioned above, Mr. Holmes found a line of faulting extending along the upper side of Roaring Fork which explained the inversion of the strata.

Below the mouth of Frying-Pan Creek on the right-hand side are low, rolling hills, the basis of which seems to be the Upper Cretaceous formation. On the opposite side, however, there are outcrops of red sandstones beneath in the bluffs. The Cretaceous strata extend to the granite of Sopris peak, seeming to rest immediately upon it, there being nothing showing between until we get on the other faces of the mountain. The geology about the southern part of the peak was referred to last year. Jurassic, Triassic, and Carboniferous layers outcrop on Rock Creek, but this region will be fully described in other parts of the report, so I merely mention it here and to return Roaring Fork.

The course of the latter stream from the mouth of Frying-Pan to the mouth of Rock Creek, a distance of eleven or twelve miles, is north 70° west, the rate of fall being about fifty feet to the mile. The valley above

*Page 265, report of 1873. †Page 263, Report 1873.

the mouth of Rock Creek is about two miles in width, and beautifully terraced. The river splits into numerous branches, inclosing islets on which are groves of cottonwoods. The terrace bluffs on the north side are about one hundred feet in height. Rock Creek enters the valley, emerging from the Elk Mountains, about three miles above its mouth. After the junction of the two streams, Rock Creek turns and flows north 25° west. Just before it turns, it flows by bluffs of red sandstone, outcropping on the north side. They dip 10° to 20° a few degrees east of north. A short distance back of the river they are capped with basalt, and covered with a growth of low cedars. The hills continue on the north or northeast side of the river until we reach the Grand. There is some slight folding at right angles to the river, allowing the gypsiferous beds to outcrop as we go down. It is only a minor fold, for Roaring Fork occupies the axis of the main fold, which is an anticlinal. On the opposite side of the river there are well-marked hog-backs, in which the strike is parallel to the course of the river, as is shown also in the parallel course of the streams draining them. A section through these hog-backs and across Roaring Fork is shown in section F, Plate IV. In the hills, farther back, there is basalt on the summits. The hog-backs extend to within about four miles of the Grand, when the basaltic capping comes so near the river as to preserve the edge of the hills and prevent the underlying beds from being eroded. The line of outcrop also curves slightly to the westward, under the capping, so that the Cretaceous No. 1, which forms the best defined hog back, is considerably farther from Roaring Fork, near the Grand, than it is near Rock Creek. At this point, then, the Red Beds are seen on top, and beneath a considerable thickness of the gypsiferous strata outcrops on both sides of the river. Those on the south side have weathered into curious pinnacle and tower like forms of pink, yellow, gray, and creamy colors. The valley of Roaring Fork is here comparatively narrow. The river and local drift is terraced, the terraces in the lower part of the valley being covered with bowlders of black basalt, from the hills back of the hog-backs. About three miles and a half above the mouth, Roaring Fork is joined by the creek draining the hog-backs, which here cuts across them and flows along the upper edge of a terrace that is 200 feet above the level of the river. The course of the river here is almost due north until it joins the Grand, just as the latter emerges from the cañon that commences below the mouth of the Eagle. The exit is through a narrow gorge in the limestones. These limestones continue along the upper side of the river, dipping generally toward the south, at an angle of 20° to 30°. The inclination is more abrupt near the river, decreasing as we go back, until, on the summit of the hills, the beds are almost horizontal. On the south side the Red Beds outcrop, forming bluffs that at some points are five hundred feet in height, rising in sheer precipices. There are probably gypsiferous beds beneath, but they are concealed by the local *débris*. A short distance back the edge of the basaltic mass capping the hills appears. Its outlines are somewhat difficult to trace in places, as it is covered with a growth of scrub oak, and scattered groves of cottonwoods. The line of outcrop of the Dakota group appears from beneath the basaltic area, and keeps along the lower side of the river, the strike being north 75° west. The beds form a series of hog-backs, the continuation of those on Roaring Fork. They extend along the Grand on the lower side for eight miles, when they cross and stretch away to the northwest, in an isolated range which gradually dies out in a plateau. A section across these hog-backs west of station 17 is shown in Fig. 2, Plate

Plate IV.

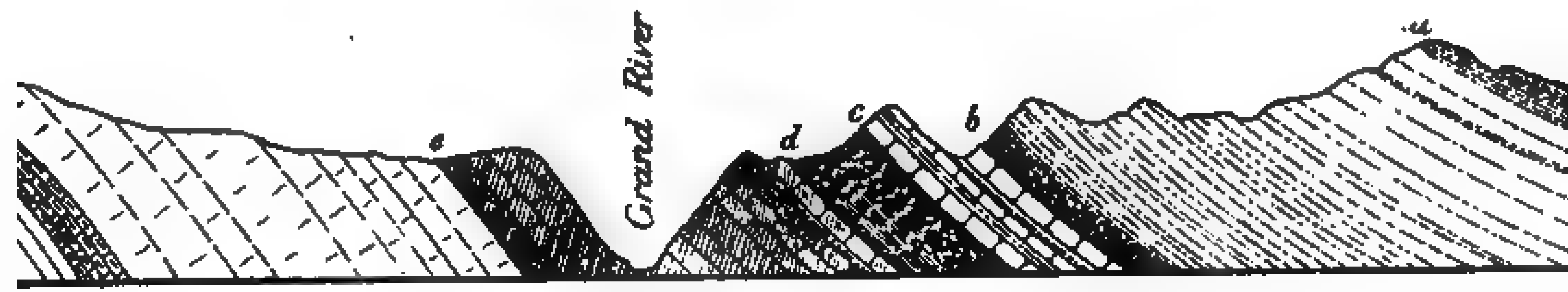


Fig 1. Section E.

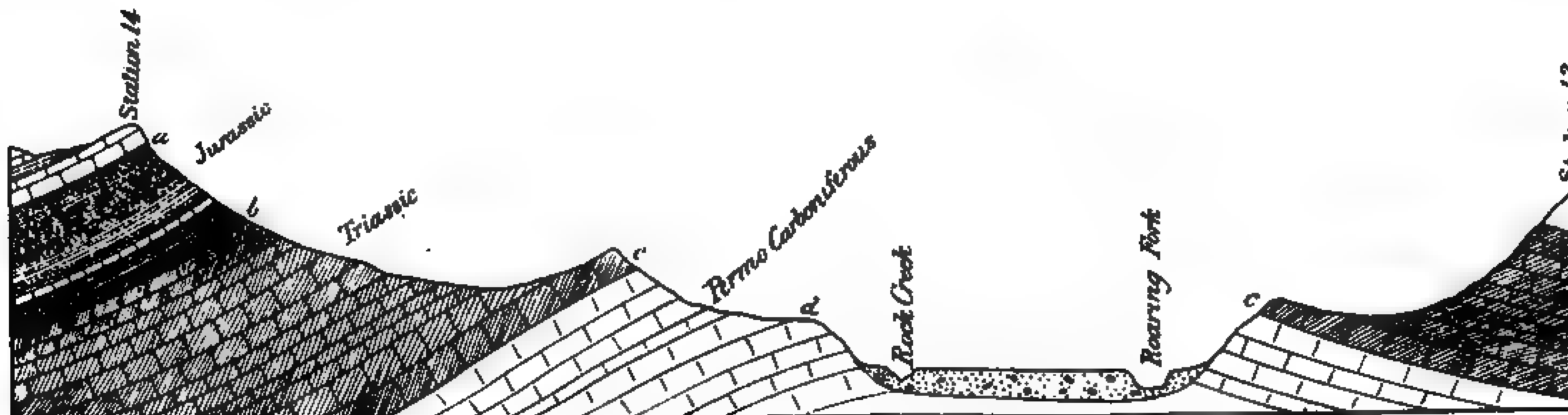


Fig 2. Section F.

IV. The valley of the Grand below the mouth of Roaring Fork is only about two miles long, the river again entering a cañon. At the head of this cañon the Red Beds cross, and are shown on both sides. The river gradually bends and follows the strike, in a monoclinal, rift for six miles, when it turns again and cuts abruptly across almost at right angles to the strike, flowing through a valley cut in the soft shaly beds that lie just above the Dakota group.

This valley is only a few miles in length, and in it the river is joined by quite a large stream from the north, which flows along the eastern base of the Cretaceous range, which I have described as ending in the plateau to the northwest. From this valley the river cuts through the strata at right angles to the strike, and comes out into a broad valley, through which it flows for fifteen or twenty miles, and enters another cañon, or rather cañon-like valley, cut in a plateau in which the beds are almost, if not quite, horizontal. This cañon is more or less persistent until the river enters the valley in which it is joined by the Gunnison. The general course of the river for about nineteen or twenty miles is south 70°–75° west. At the head of the valley the bluffs are almost vertical, and, indeed, in some places, the cliffs, as seen in certain lights, appear to overhang. At the point where the course changes to the southward, the valley is wider, and the Grand splits, forming islands in the midst of the river. This is northwest of station 50. The plateau here, between the Grand and Plateau Creeks, is narrow, and has in reality degenerated into a ridge from which the basaltic capping has been removed.

Returning to the valley above the cañon, we see that it is from fifteen to twenty miles in length, and that the drainage on the south is principally through two streams, one in the eastern portion and the other (North Mam Creek, see map E) on the western side. They rise in the plateau forming the divide between them and the head of the North Fork of the Gunnison. The eastern branch is formed by two streams, whose courses are almost parallel. Between the East Fork and Roaring Fork there is a smaller creek (*c* creek, Grand River), which rises in a mass of rounded hills, which I referred to when speaking of the hog-backs on the west side of Roaring Fork. Between this creek and the plateau south of the cañon there are several folds, the axes of which are parallel, each being northwest and southeast.

The rocks underlying the valley are all of Cretaceous age, capped irregularly in places with basalt, especially on the divide. Here the strata are almost horizontal, inclining, if at all, only a few degrees toward the west in the eastern portion.

The line of hog-backs before referred to, extending along the lower side of the Grand from station No. 16, through station 18, and crossing the river, forms the side of a synclinal fold, the axis of which is, partially at least, occupied by a creek (*c*, Grand River). The dip of the strata is southwest, inclining at an angle of about 15°; this increases as we go toward the Grand, being about 60° there.

Station 20 is on the opposite side of the fold, the dip of the sandstones there being northeast at an angle of 15° to 20°. From station No. 19 to 22 there is a mesa covered with basaltic bowlders. I am inclined to think also that there is a capping of the same material. The bowlders are derived from the hills near the divide. The mesa is about a mile wide and slopes gently toward the Grand. It is about 400 feet above the valley of the creek at the forks below station No. 19. At station tion No. 22 it is 800 feet high.

Between the forks of the large creek east of North Mam Creek, the

hills are capped with basalt. The elevation of station 24 is 10,642 feet, and station 25, 9,031 feet. There is but little timber here, the summits being grassy and park-like. In some few places there are pines, but cottonwoods are more abundant. In the hills east of station 24, and on the lower slope, there is scrub-oak (*Quercus alba*) in abundance. The small creeks rising in the Cretaceous shales we generally found strongly impregnated with alkali.

The western branch of the creek referred to above, heads in beautiful meadows. Its course here is nearly due west. After flowing in this direction for five miles it turns and flows to the northwest, gradually crossing to the western side of a low, broad anticlinal. The strata on the east incline 5° to the northeast, and on the opposite side from 5° to 10° in the opposite direction. Beyond, the beds probably become horizontal, as seen in the high white cliffs east of station No. 48, on the edge of the plateau.

In looking down upon this valley from the hills bordering it, it appears more open than it really is, for we find that it has numerous hills or buttes in which the sandstones outcrop. They are gray, chocolate-colored, and greenish. We were not able to visit them, but noted them from the stations on the east side and from the plateau.

We were not on the Grand River in this valley nor on North Mam Creek, which joins it above the cañon. North Mam Creek flows along the eastern edge of the plateau from which some of its branches are derived. Its general course is north 15° east.

The branches of the Grand from the south in the cañon valley north of the plateau are all small and unimportant, simply draining the plateau. The next branch of importance is Plateau Creek flowing into the Grand 50 or 60 miles below the head of the cañon. It is a stream of considerable size, deriving its water principally from the mesa divide on the south, the branches heading in the plateau of station 48, carrying water only in the spring and early summer.

There are two principal streams uniting to form the creek, one (*f* creek, map E), having its sources opposite those of the northern branches of the North Fork of the Gunnison, and the other (*g* creek, map E), rising more to the north and eastward, opposite the head of North Mam Creek. The branch first mentioned is the largest. Its course is generally north. A few miles above its mouth, however, it turns abruptly and flows westward, parallel to the other branch, leaving a flat-topped terrace between. It rises on the divide, in beautiful park-like meadows, among low hills whose rounded outlines are covered with groves of quaking aspens whose foliage in the fall of the year is of a rich golden hue, contrasting boldly with the dark green of the pines found on the higher points. These groves abound in game, and are favorite hunting-grounds of the Indians. We found their trails leading in almost every direction. Near the head of the creek are outcrops of soft shaly beds covered in some places with basalt which forms rough points reaching above the general level. In the valleys the soil is made of the *débris* from the shales mingled with pebbles from the erosion of the basaltic layer which once formed a capping to the plateau. Scattered over it are chips of chalcedony and agate. The sedimentary beds are nearly horizontal. As we go down the valley we find the creek cutting deeper and deeper into the soft strata, leaving high terraces between the branches. Between camp 44 and camp 45 the river falls 2,583 feet, which is about 200 feet per mile. In the lower part of the valley there are outcrops of soft gray sandstones. The terraces are partially covered with scrub-oak, which make traveling somewhat difficult. The other branch has a much more open

Plate V.

Bluff on Plateau Creek.

valley. It rises among low hills, and has a much more gradual fall to its mouth. It is about 24 miles in length, and forms a portion of the boundary-line of the plateau of station 48. Between the parallel portions of the two streams just described there is a terrace, the height of which is about 80 feet, at the bend of the first branch. It is about a mile wide here and slopes to the forks, where it terminates in a point, the entire length of the bench being about seven miles. It is covered with good bunch-grass, and has evidently been used by the Indians as a grazing-ground for cattle. The plateau between this creek and the Grand River is approximately triangular in shape, the base being on the eastern side. Here it is 15 miles in width. To the west it gradually terminates in a ridge, which extends between the two streams. Its length is 15 miles, and its mean elevation, where the general level is best preserved, is about 10,200 feet. It was once, doubtless, continuous with the mesa or plateau which still exists to the southward. Erosion has isolated it. The covering of basalt which once covered it has been partially removed. The remnants left reach from 200 to 250 feet above the general level, forming monument-like points that are visible from a great distance. Station 48 was located on one of these points, a conical mass 248 feet high. The eastern edge of the plateau, as I have already mentioned, has steep bluffs, overlooking a broad valley. On the north side, also, are bluffs, which as we go down the Grand become less steep, a number of small streams cutting them into small hills. Toward the eastern side the beds are nearly horizontal, but as we go west we find that there is a slight dip to the east, or perhaps a little north of east. The southern side of the plateau, near station 48, has a number of creeks draining it, the courses of which are nearly parallel, flowing south. Between them are sharp ridges, at the base of which gray and pinkish sandstones outcrop. On top are light clayey beds and interlaminated hardened shales, weathering a white color, thus giving the bluffs a unique appearance, as seen from a distance. Underneath the basalt, the beds are concealed even on the edges of the plateau. As we go down the creek the valley widens on both sides. On the south are drift-covered terraces sloping from the divide. On the north side are low bluffs, close to the river, in which pink and yellowish strata outcrop. These beds are cut into terraces, beyond which are bluffs of variegated sandstones, passing above into light colored shales. On the latter, station 50 is located. From station 50 to the Grand the descent is at first rather abrupt. Then there is a gradual slope broken up by the drainage into low buttes. The Grand has a broad bottom, through which it flows sluggishly.

South of the station the country is very nearly the same. There are magnificent exposures of the strata, which are inclined but slightly. On the north side of Plateau Creek are bluffs of sandstone, through which the stream cuts rapidly to soft shales, which weather in the most peculiar manner, as shown in one of the illustrations, Plate V. Above the black argillaceous columns are yellow sandstones, and the *débris* from them has fallen down, capping the summits of the pillars. Below, still lower beds are shown, until a belt of red sandstone is seen opposite Mesa (*a*) Creek. It here enters a cañon, in which it keeps until it joins the Grand. Almost all the creeks in this region cut profound cañons; even the smallest rivulets cut gullies from eight to twenty feet deep.

The terraces are covered with basaltic bowlders, and are almost destitute of vegetation. Good grass, however, is found in the alluvial bottoms bordering the creek. Scrub-oak and stunted cedars are found on the hills. The cañon on Plateau Creek is eight miles long. Below its mouth,

the Grand and its branches cut fearful-looking chasms in the soft rocks. Looking down upon them it is hard to trace the courses of the streams, as it appears to be an inextricable maze of gorges.

There is great variety in the colors; reds, greens, grays, yellows, mingle with chocolate-browns, and white, in parallel lines, which repeat themselves in the different layers.

At the head of the cañon of Plateau Creek the Indian trail we had been following leaves the creek, goes up Mesa Creek, and skirting the edge of the mesa, leads down into the valley of the Gunnison.

The course of Grand River below the mouth of Plateau Creek is generally southwest, and sometimes due south.

It flows in this direction until it comes out into the broad valley, in which it is joined by the Gunnison. It emerges from the cañon by cutting its way across a line of hog-backs, almost at right angles to the strike of the strata, the beds dipping about northeast at an angle of 10° to 15°.

Plate VI represents the bluff on the north side of the river, as it comes from the cañon into the broad valley.

The numbers in the following section correspond with those in the illustration.

BASE.

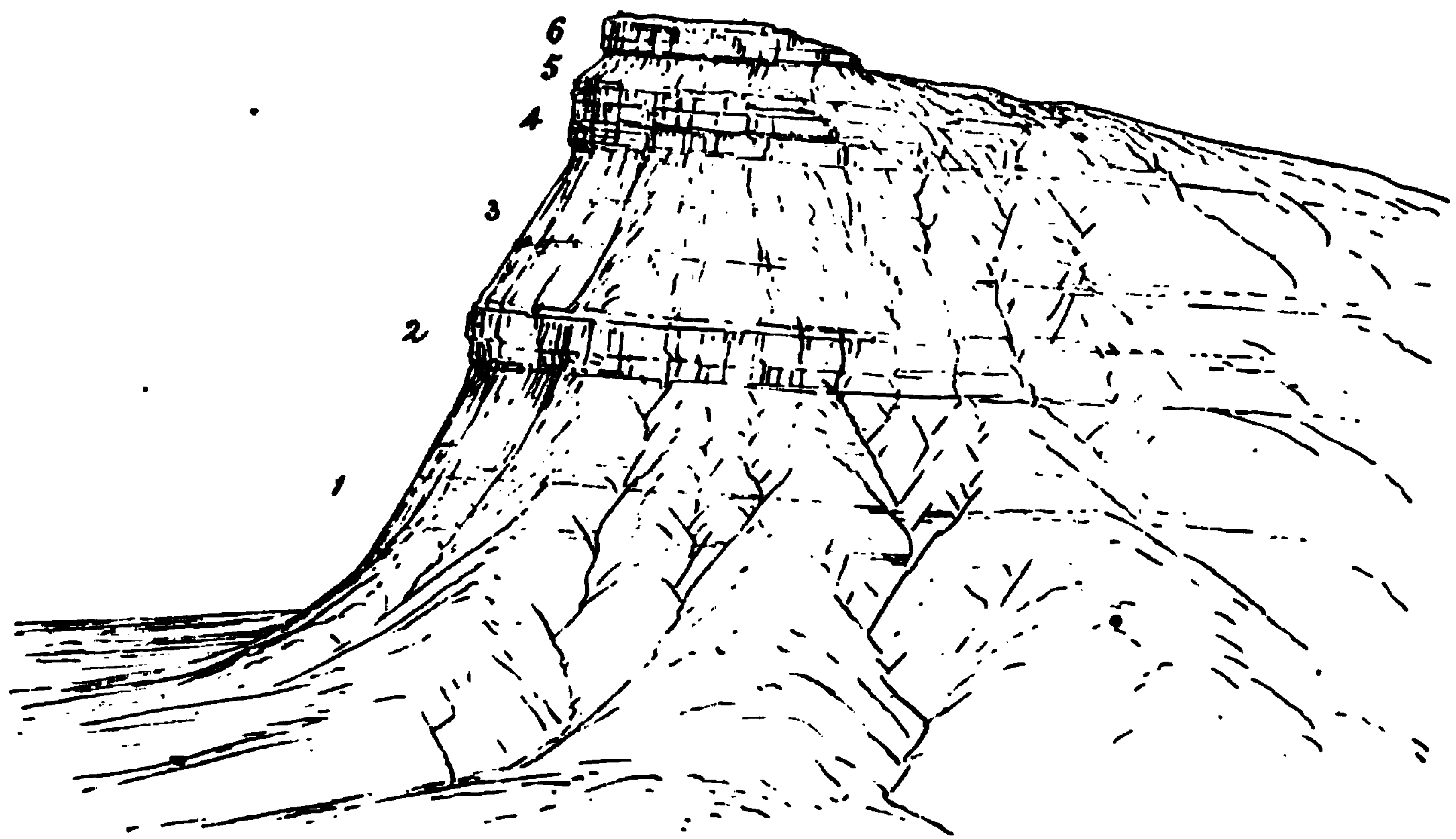
1. Black and yellow shaly beds.
2. Yellow sandstone.
3. Yellow shaly beds.
4. Sandstones.
5. Shales.
6. Sandstone with pinkish hue.

This section was made from the opposite side of the Grand, and could not, therefore, be made in greater detail. The beds were measured by angles taken with the gradienter. The height of the bluff as thus determined is 1,890 feet. On the south side of the river the inclination of the beds causes them to disappear, while higher ones show beneath the basalt of the mesa. The slopes, reaching from the edge of the mesa in terraces, are covered with basaltic bowlders, among which we found numbers of moss-agates (none of good quality, however) and pieces of chalcedony.

West of the line of hog-backs, which extend toward the northwest from the Grand, the valley is about eighteen miles in width, reaching to the northwest as far as could be seen. Near the Grand, before the Gunnison comes in, it is very flat and covered with spots of alkali. On the south side of the Grand, in the angle between it and the Gunnison, are terraces, the first of which is one hundred feet high, and the second nearly two hundred feet. The contrast between the two rivers is quite marked. The Grand has nearly twice the volume of the Gunnison, and and carries a vast quantity of mud with it. Wherever we reached the Grand throughout the entire season it was muddy. The reason is, that along the river there are many exposures of soft shales and clays. The Gunnison, on the other hand, is a clear stream, and remains so except when there are heavy rains, when it becomes very turbid in the lower portion of its course.

The divide between the Grand and Gunnison Rivers has been so often referred to in this chapter that only a few more words are necessary to complete its description. In the Elk Mountains the line of the watershed is very irregular, the mountains rising in sharp peaks, at the bases of which the streams head in amphitheaters, sharp ridges connecting

Plate VI.



Bluff on Grand River near the Mouth of the Gunnison.

the peaks and separating the various streams. This portion of the divide, however, was in the district of 1873, and we have to do here with the portion west of the Elk Mountains, where it presents characters entirely different, being mostly a plateau, from the fact that the beds underlying it are almost horizontal and covered with a flow of basalt. The plateau character is best shown toward the west, where the basaltic capping is for the most part intact.

West of Rock Creek, at the head of the North Fork of the Gunnison, the plateau is broken into low rolling hills, of which the general level is very nearly the same. The basaltic capping here is very irregular and difficult to define, as a great portion of it has been removed by erosion. The hills and also the beds of the streams are covered with round masses of the rock. At station 45 there is more basalt in place. The streams rising near have their origin in small lakes. All over the plateau these lakelets may be found, and along the creeks are beautiful meadows. The timber on the plateau is pine and quaking aspens (*Populus tremuloides*). There is good grass in most of the valleys. The western edge of the plateau is somewhat irregular but sharply defined, forming a bluff edge of from two hundred to four hundred feet in height. It is underlaid with sandstones, as will be shown in the sections given in a subsequent portion of the report.

CHAPTER III.

SURFACE GEOLOGY—GUNNISON RIVER AND ITS TRIBUTARIES.

Gunnison River is the principal branch of the Grand, on the south side. It rises on the western side of the Sawatch range, opposite the Arkansas River, and on the southern side of the Elk Mountains, opposite Roaring Fork. Its total course has a length of about two hundred miles, the average rate of fall per mile being about thirty feet. In Gunnison's and in Frémont's reports it is called the Grand. In the West, however, it is now known as the Gunnison River, the name Grand being given to the principal stream, as already mentioned in a previous chapter. The principal branches of the Gunnison on the south are Cochetopa Creek, Lake Creek, Cebolla Creek, and Uncompahgre River. Those on the north, in our district of this year, are Ohio Creek, Smith's Fork, and the North Fork. The entire area drained by all the branches on the north is about twenty-six hundred square miles. From the mouth of Cochetopa Creek, the Gunnison flows a few degrees south of west, to Lake Fork; here it changes and flows west, gradually turning to the northwest until it is opposite station 80, a distance of nearly thirty miles; when it again turns and flows nearly due north to the mouth of the North Fork; where it turns abruptly and flows west to the head of what the Indians call Unaweep Cañon. * Its course thence to its mouth is generally northwest.

There are three large cañons and several small ones in the course of the river, which will be described as we reach them in going down the stream. The upper one is in granitic rocks, and was described last year. The drainage of the streams uniting to form the Gunnison near its head flows in two directions, viz, southeast or south-southeast, and southwest. In this part of its course it is within last year's district, and will be found described in the report for 1873.

Our work last year extended as far west as Slate River, and we commence this year, therefore, with Ohio Creek, the next stream coming into the Gunnison on the north side.

In an air-line, from the head of Ohio Creek to its mouth the distance is twenty-two miles. The actual length, however, is nearer thirty miles. It has its origin in a group of isolated peaks that mark the termination of the Elk Mountains to the westward. Its sources are opposite those of Slate River on the north and east, and those of Anthracite Creek, a tributary of the North Fork of the Gunnison, on the northwest. It has two forks which unite below a high sugar-loaf peak of porphyritic trachyte, station 30. The western branches have their origin in a group of mountains made up almost entirely of breccia, which in all probability rests on sandstones of Cretaceous age.

The most northern of these streams flows along the southern edge of a short range of sharp peaks, whose slopes are destitute of timber, and which form a serrated edge along the summit. This mass is composed of porphyritic trachyte and forms a portion of the divide between

* Pacific Railroad Report, vol. ii.

Ohio Creek and Anthracite Creek. A trail crosses through a low pass from the head of the latter creek and keeps down Ohio Creek and then follows up Cochetopa Creek to the Los Pinos agency. This is one of the main Indian lodge-pole trails, connecting Los Piños with the White River agency.

Between East River and Ohio Creek are two mesas, isolated one from the other and underlaid by Cretaceous shales and sandstones. These mesas are composed of trachyte, judging from the *débris* covering the slopes west of Ohio Creek. The trachyte is probably of the same character as that on the opposite side of East River noted in last year's report,* a light purplish rock. As I have already mentioned, the hills on the west side of Ohio Creek are made up almost entirely of breccia. I will refer to it particularly in a subsequent portion of the report. I think, judging from several outcrops seen on some of the western branches of the creek, that it rests throughout the greater part of its extent upon sandstones.

The western branches rise in these hills and cut deeply into the breccia, which seems to yield readily to the action of water. It appears to be in layers, and erosion has worn it into fantastic forms. In places, there are castellated masses from which towers and minarets rise; while in others, huge buttresses stand out prominently against the sky. Station No. 31 is situated in the midst of this mass of breccia. (See map D).

The valley of Ohio Creek is from a mile to two miles in width and has a beautiful grassy bottom, with groves of cottonwoods. The hills on the west are heavily timbered with pines, extending down the ridges between the branches. On the lower slopes near the creek there is sage-brush (*Artemisia*).

The valley of the Gunnison above the mouth of Ohio Creek is very wide, extending from a short distance below the mouth of Slate River to Cochetopa Creek, a distance of ten or twelve miles. It is from four to seven miles in width. The river-bottom in places seems to be quite fertile, and at one place we found a garden in which potatoes, beans, turnips, cabbage, and lettuce had been successfully raised during the season.

The southeast side of the valley, reaching toward Cochetopa Creek, is rather sterile-looking, there being but little soil. It is very level and covered with pebbles derived from the Elk Mountains. There is a sparse growth of grass and low sage-brush. The Gunnison here is a rapid and very clear stream of a hundred or a hundred and fifty feet width. It keeps close to the bluffs of breccia below the mouth of Ohio Creek.

This valley is the site of a new town called Gunnison City. There were half a dozen log-cabins, most of them in an unfinished state and without inhabitants. The only persons we found living in the valley were the two men who have charge of the cattle for the Indians of Los Pinos agency. They were at the cattle-camp, a short distance above Cochetopa Creek. Below Cochetopa Creek the valley again expands into a grassy meadow, from which the river enters a cañon. Men from the agency were busy cutting grass in this meadow while we were there. The hay made is for the use of the agency and the cattle-camp. The cattle are allowed to run wild among the hills throughout the year and seem to do well. The country is much better adapted to stock-raising than for agricultural purposes. The elevation of the cattle-camp is 7,743 feet.

The lower valley is about four miles long and two miles wide in its greatest width. On the northern side the breccia forms the boundary,

* Page 249, Report 1873.

trachyte capping it as we go toward the hills. On the south side the rocks are gneissic, as they also are in the cañon. At the upper end of the valley, on the north side, is an outcrop of soft yellowish gray sandstone. Farther down the breccia, instead of resting on this sandstone, appears to be directly upon the schists. At station 71, however, between the schists and the breccia there is a belt of sandstone that seems to have been metamorphosed. Above the breccia there is a capping of trachyte.

The cañon is only about a mile and a half in length, and in it the river has rather a tortuous course, flowing at first south of west and afterwards north of west. The walls are not very high, never exceeding 300 feet. Below, the river is in another valley similar to the one above. This, however, is not as large, being only two miles long and a mile wide in the widest portion. It is not so well grassed as the valley above. The schists still compose the hills on the lower side, while on the north there are sandstones, breccia, and trachyte in long mesa-like ridges that extend from the margin of the valley toward the hills in which station 31 is situated.

Leaving this valley the river again goes into cañon and keeps so almost all the way to the mouth of the Lake Fork, broken only by small and unimportant valleys. The rocks in which the river-channel lies are schists, and the walls never exceed about one hundred and fifty feet in height. This granitic rock forms a narrow strip, leaving a bench or shelf on both sides of the river, reaching back to the edge of the bluffs.

On top of the schists, forming the base of the bluff, are the sandstones that probably belong to the Dakota group. As we proceed down the river we find on top of these, black and yellow shales, above which is the breccia to which I have so frequently referred in this chapter. This, in a great many places, has weathered into sharp pinnacles and towers. It is capped with obsidian and trachyte.

A section of thebluffs will be given in another place, when the different layers will be particularly described.

These bluffs are on both sides of the river, and form the edge of the mesas that are so characteristic of this part of the valley of the Gunnison, extending back from the river on both sides.

Below station 71 the top of the mesa is about 500 feet above the river-level, and at station 73 it has increased to 1,230 feet, the general surface really remaining at the same level on both sides, while the river in its progress has cut deeper and deeper, making the bluffs nearly twice as high. This height is still greater farther below, as we will find when we speak of the cañon.

The streams joining the Gunnison cut deeply into the surface, dividing the original mesa into many others. The cañons thus formed have almost perpendicular walls. There appeared to be more than one layer of the trachyte, for, from the edge of the mesa a higher outcrop can be seen. I was not able this year to determine definitely the relations between the trachytic flows and the breccia on the mountainous mass around station 31. Another year I hope to explain it.

Above the mouth of the Lake Fork, the Gunnison flows through a small open valley covered with grass and sage-brush, in which it is joined by a branch of some size from the north. From this valley the river plunges into the largest cañon in its entire course. Lake Fork is itself in a deep cañon, cut through dark, micaceous schists, and until one comes to the edge of the gorge, he has no idea of its size or extent. Gunnison's wagon-trail is obliged to cross it a long way back from the river, and come down the stream on the opposite side.

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A section of thebluffs will be given in another place, when the different layers will be particularly described.

These bluffs are on both sides of the river, and form the edge of the mesas that are so characteristic of this part of the valley of the Gunnison, extending back from the river on both sides.

Below station 71 the top of the mesa is about 500 feet above the river-level, and at station 73 it has increased to 1,230 feet, the general surface really remaining at the same level on both sides, while the river in its progress has cut deeper and deeper, making the bluffs nearly twice as high. This height is still greater farther below, as we will find when we speak of the cañon.

The streams joining the Gunnison cut deeply into the surface, dividing the original mesa into many others. The cañons thus formed have almost perpendicular walls. There appeared to be more than one layer of the trachyte, for, from the edge of the mesa a higher outcrop can be seen. I was not able this year to determine definitely the relations between the trachytic flows and the breccia on the mountainous mass around station 31. Another year I hope to explain it.

Above the mouth of the Lake Fork, the Gunnison flows through a small open valley covered with grass and sage-brush, in which it is joined by a branch of some size from the north. From this valley the river plunges into the largest cañon in its entire course. Lake Fork is itself in a deep cañon, cut through dark, micaceous schists, and until one comes to the edge of the gorge, he has no idea of its size or extent. Gunnison's wagon-trail is obliged to cross it a long way back from the river, and come down the stream on the opposite side.

Plate VII

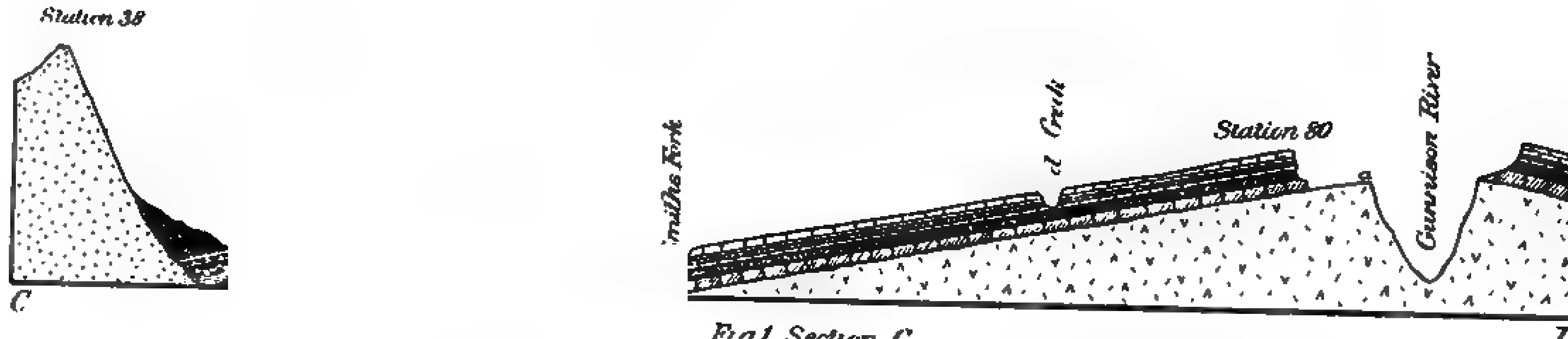

Fig 1. Section. C

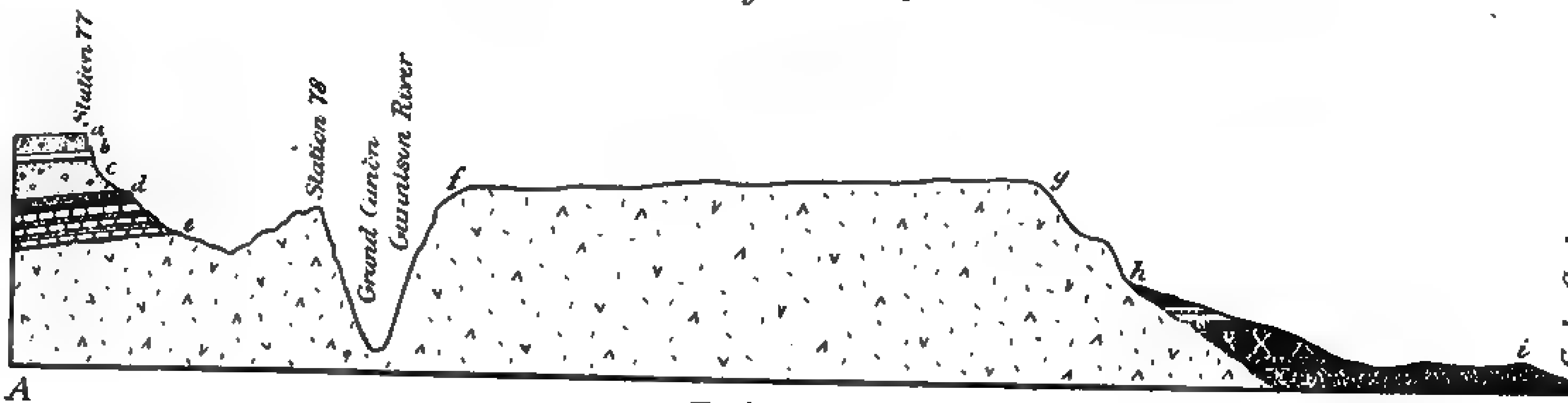

Fig 2 Section H

The country between Lake Fork and the Uncompahgre River is rough and rugged. The streams cut deep cañons to join the Gunnison. Mountain Creek, Blue Creek, and Cebolla Creek are the principal streams draining this region. Blue Creek, to which I have just referred, is placed on Gunnison's map, as a branch of Cebolla, whereas it is a tributary of the Gunnison.

The mesas are found on Mountain Creek, and until we reach Cebolla creek. Here we meet with cretaceous shales, seeming to be horizontal, and resting on granite. The granite in places has trachyte resting on it. I noticed it on the hills east of Cebolla Creek.

The great cañon of the Gunnison is about fifty miles long. In it the course of the river at first is west; it gradually changes toward the north, and at station 80 flows northwest, gradually becoming due north, which course it keeps rather uniformly to the mouth of the North Fork.

From the head of the cañon to the mouth of Smith's Fork the main portion is cut in dark micaceous schists. It has its greatest depth, perhaps, opposite station 77; the height from the water to the top of the mesa on which the station was located being about 3,000 feet. The granitic portion is about 2,000 feet deep. It was, of course, impossible to reach the edge of the river while in the cañon, so that these figures are not perfectly accurate. They are obtained by comparing the heights of stations 77 and 78 with that of camp No. 53, on Cebolla Creek, about one mile above its mouth, and allowing for the fall of the river between the two points. The error, if any, would, therefore, be very small and in favor of greater depth.

The section across the river, through stations 77 and 78, is shown in Figure 2, Plate VII. On the west side of the river is a plateau about four miles in width and thirteen miles long. Its elevation above the river is 2,500 to 3,000 feet. It is composed of schists, and the top seems to have a gentle slope to the eastward. It seems to have had in places a capping of trachyte.

East of Cebolla Creek, on the granite hills, a portion of this trachyte still remains. To the northward the plateau runs to a point, the termination being marked by a high conical point of granite. Beyond this, are red sandstones (Triassic), with superimposed Jurassic and Cretaceous strata, as seen from station No. 80, on the opposite side of the river. Fig. 1, Plate VII, shows a section through station 80. It will be seen that the granite forms a sort of shelf along the river, on which the sedimentary formations rest, having bluff-like edges a short distance farther back. These beds incline at a small angle (about 5°), causing the country to slope gently toward Smith's Fork, which here flows almost parallel to the Gunnison. The illustration, Fig. 1, carries the section across Smith's Fork. Beneath station 80 is an outcrop of the Red Beds. Where the section crosses Smith's Fork, the latter stream does not cut below the Dakota group (No. 1). Near the mouth, however, it cuts through the Red Beds reaching the granite.

Smith's Fork joins the Gunnison as the latter emerges from the granitic portion of its cañon, and cuts across the strata into the Cretaceous sandstones. It rises in the group of trachytic peaks that I have already referred to as terminating the Elk Mountains to the westward. Before it leaves these peaks there are outcrops of Cretaceous shales seen near the water's edge, on the main creek at first, but afterward spreading out and covering wider areas. After it is fairly out of the mountains it flows across the Upper Cretaceous formation, and gradually cuts through the sandstone of No. 1, which forms bluffs extending along its course from the mouth of the Southern Fork to the mouth. (See map B).

Grand, immediately opposite the plateau in which station 48 was located. Its course is nearly south, on a line with Coal Creek. The valley is comparatively narrow, there being but few open bottoms along its course. The slopes of the hills on either side are well timbered with pines and cottonwoods. Near the head of the main creek there are large bowlders of a black basalt, derived, in all probability, from the layer which once covered the entire divide. While on this creek we met a party of prospectors, who said they had found indications of gold along the stream, but not in any very great quantity.

The divide between Rock Creek and this branch of the North Fork is a sharp ridge of Cretaceous sandstones, reaching above the timber-line. The strata dip about 15° to the west, the angle decreasing on crossing the North Fork, until they become almost horizontal in the plateau divide between North Fork of the Gunnison and Grand River. Station 26 was located on this ridge. The lines of outcrop between the station and Sopris peak are the prolongation of the hog-backs on the west side of Roaring Fork.

The rock on the summit of station 26 is a compact greenish-gray sandstone, somewhat laminated, and containing in the lower part fragments of stems and leaves, and particles of carbonaceous material. The most careful search revealed nothing perfect enough for identification. Below this sandstone is a narrow band of dark-colored, very compact limestone, of a reddish-brown color on the weathered surfaces. Next below is a coarse-textured, soft, gray sandstone, which seemed to continue to the base of the amphitheater which the station overlooked.

Near the base of the slope we ascended, I noticed an outcrop of conglomerate in which the pebbles were of a rock very much like that forming the nucleus of the Elk Mountains. The matrix was siliceous. What the relations of this bed were to the sandstones I could not determine, as the slopes were covered with a heavy growth of timber, and the underlying beds were for the most part covered with *débris*. The pebbles were rounded and evidently water-worn.

South of station 26 the strike curves to the eastward, the dip changing more and more toward the southwest. The line of outcrop of the Cretaceous beds crosses Rock Creek into the Elk Mountains, where they become very much faulted and upturned. In this portion of the Elk Mountains Dr. Hayden made a more detailed survey, and to his report and the report of Mr. Holmes, the reader is referred for the geology of Rock Creek and the adjacent peaks.

Station 33 was located south of station 26 on one of a group of high peaks, rising from a mass of trachyte resembling that composing the mountains between Anthracite Creek and the head of Ohio Creek near station 32.

The western slope of this mass is extremely steep, the sandstone reaching to the base, almost horizontal in position. At the northern end, however, as seen from a distance, the strata appear to dip to the northeast at an angle of about 40°, so that there would seem to be a synclinal fold between this point and the ridge, extending from station 26. A branch of North Fork rises here and flows nearly due west. Near its mouth the beds are also inclined towards the northwest, although the angle is only about 5°.

At the southern end of the mass in which station 33 is situated, on Anthracite Creek, the sandstones are tipped up, dipping north 54° west at an angle of 15°. Dikes of trachyte penetrate the sandstones. The branch of North Fork that we have just been considering, after the union of the

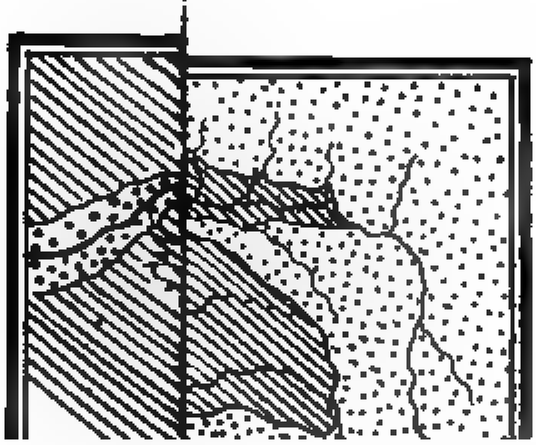

PHOTO-LITHOGRAPHER, WASHINGTON, D. C.

streams heading in the plateau, flows for a short distance through a beautiful grassy valley, from which the country on the west rises in a plateau which is timbered on the slopes.

At the lower end of the valley the stream gradually cuts deeper and deeper into the sandstones, until, at the point where it meets Anthracite Creek, it is about a thousand feet below the general level. All the branches here, even the smallest, cut these cañons, leaving mesas or tables between, in which the strata are nearly horizontal, thus giving them about the same general level.

After the union of the two main creeks, the North Fork flows a little south of west, almost at right angles to the former courses, in a cañon which is from 1,500 to 2,000 feet deep. This cañon is about fifteen miles long. In the lower part the river gradually turns to the southward, finally emerging into a rather broad, open valley extending on the lower side to the foot of the hills on which stations 38 and 39 are located. The valley becomes wider as we go toward Smith's Fork. It is comparatively open, being broken only by low hills or buttes of yellowish and gray shales, all belonging to the Cretaceous formation. These buttes have a scattered growth of stunted cedars and sage-brush. The soil is impregnated with alkali, and generally sterile. The small streams cut deep gulleys in the soft beds. As the river emerges from the cañon the mesas on the south side end abruptly in steep bluffs, just north of station 39. Stations 38 and 39 belong to the trachytic group, to which I have already so often referred. They are beautiful examples of mountain forms, rising in sharp conical points. Station 38 rises 4,000 feet above the general level of the valley which it overlooks. As already described, there is a gradual slope from the Gunnison to Smith's Fork, the sandstone of the Dakota group forming the floor. Crossing Smith's Fork, the softer beds, which we have already described, form lines of buttes. Along the North Fork there are outcrops of black shales, in which the general dip is to the northeast. On the north side of the river is a series of terraces sloping from the basaltic-capped mesa which here forms the divide between the Grand and Gunnison Rivers.

Leaving the mesa cañon the North Fork turns still more toward the south, and flows southwest to within about four miles of its mouth, when its course becomes due west. In this valley the river winds in graceful curves, outlined in the most distinct manner, as seen from the mountains and plateau, by the fringes of cottonwoods on its banks. Just before it turns to the westward it enters a cañon. The walls, at first, are mere bluffs, cut in the black shales that lie immediately above the Dakota sandstone. By the time it joins the Gunnison it has cut pretty deeply into the Dakota group. The river in this part of its course is parallel with Smith's Fork, and joins the Gunnison in the cañon at right angles to the former course of that stream. The Gunnison, however, turns and flows to the westward in the direct line of the North Fork.

This part of the cañon of the Gunnison is ten miles in length and with walls from 400 to 500 feet high. Although in many places the bluffs rise in sheer precipices from the river's edge, in others there are alluvial bottoms, sometimes on one side and sometimes on the other. The general course is about due west.

Fig. 3, Plate VIII, represents a section across the Gunnison through the line E F, on map B. At *a* it cuts the river just above the mouth of Smith's Fork, before it leaves the granitic cañon, and at *d* it cuts the river below the mouth of the North Fork. It will be seen that there is

a slight synclinal fold between *c* and *d*, which is more marked farther west, as shown in Fig. 2, which is a section across the Gunnison just before it leaves the cañon, on the line G H. The following is the section represented in Fig. 3, the figures corresponding with section L.

SECTION.

1. Granite reaching to edge of the river.		
2. Red sandstone		(*Triassic?*).
3. Greenish and gray shales and sandstones		(*Jurassic?*).
4. Shaly sandstones.	*Dakota group.*	*Cretaceous.*
5. Massive sandstones.		
6. Laminated sandstones and black shales.		
7. Black shales.		
8. Dark yellow shales.		
9. Light yellow and gray beds.		
10. Terrace with light-colored shales.		

At *a* in Fig. 2, Plate VIII, the strata are seen to be curved abruptly, the river occupying the axis of an anticlinal fold. This is at the point where it leaves the cañon. The fold, however, is not simply a north and south fold, for, as we see in Fig. 1, Plate VIII, there is folding east and west. This is the main fold, or rather the termination of the anticlinal fold, the axis of which the Gunnison follows in the cañon above Smith's Fork.

Fig. 1 represents a section on the line I K, almost at right angles to the sections in Figs. 2 and 3.

The following are the beds represented in Fig. 2 (Section K):

1. Shaly sandstones.	*Dakota group* (No. 1).	*Cretaceous.*
2. Massive sandstones.		
3. Shales and sandstones.		
4. Black shales.		
5. Yellow and gray shales.		

In Fig. 1, the following is the section (Section I):

1. Sandstones of No. 1, Cretaceous.
2. Yellowish and black shales.
3. Fine hard brownish shales.
4. } Shales forming terraces.
5. }

As we go south along the west side of the cañon of the Gunnison, we see that the dip, at first, is to the northwest, gradually coming around to the west. The connection between the Dakota group and the overlying shales seems to be broken. Opposite station 80, the Red Beds (Triassic) are seen resting on the schists. A little farther south the Dakota group is washed off, and there are simply remnants of the red sandstones left. I did not have time to visit this from the west side, and until this is done, all opinions must, to a certain extent, be conjectural. As we go farther south we find the granite plateau, before referred to, shown in Fig. 2, Plate VII, *f* to *g*, standing between the Gunnison and the valley of the Uncompahgre. Abutting against this plateau, at the head of Cedar Creek, and on the branches of Cebolla Creek, as we have already seen, the Cretaceous shales are horizontal. Whether the fold noticed at the northern end of the cañon becomes a

Plate VIII.

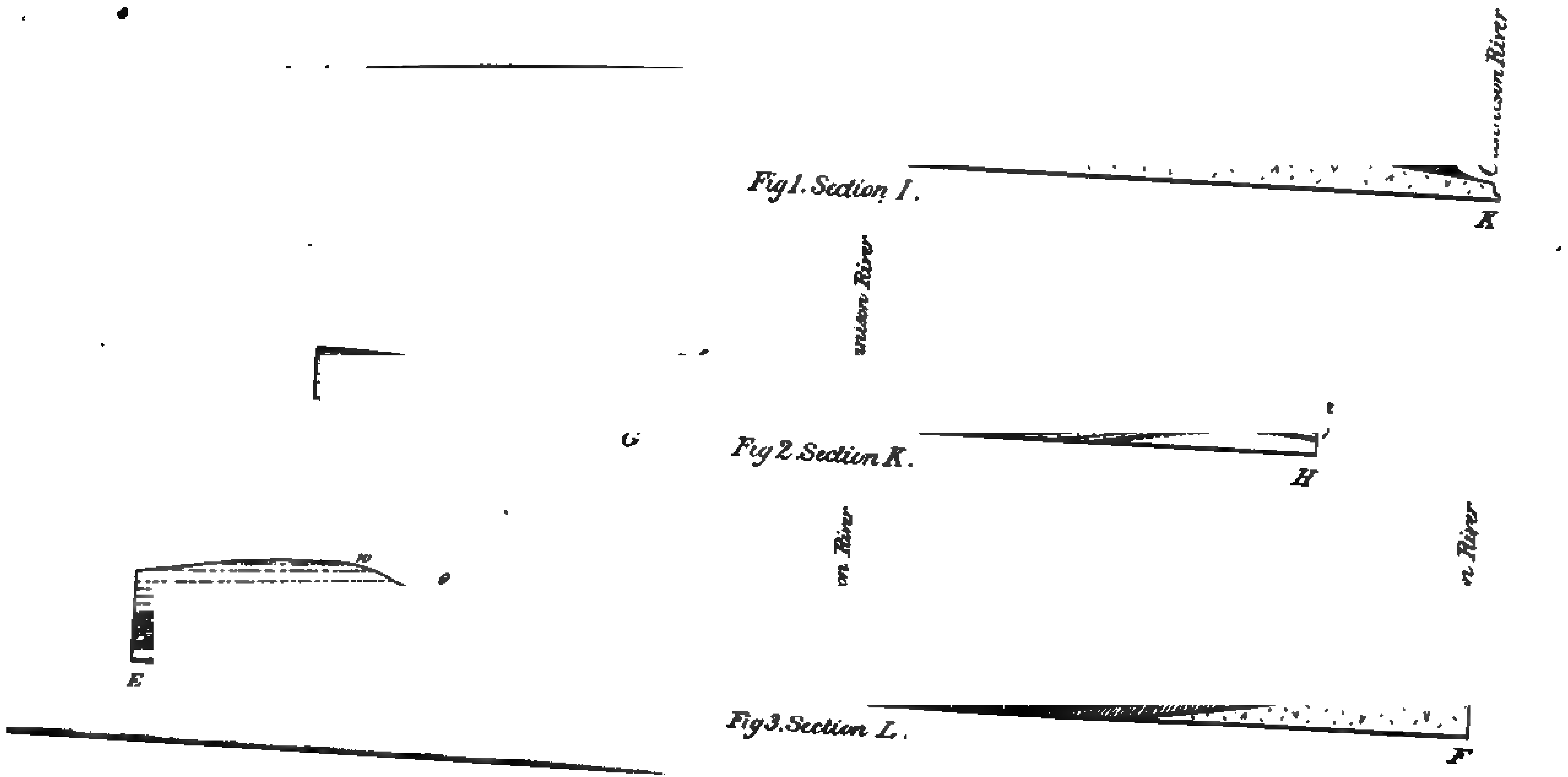
Fig 1. Section I.
K
...nison River
Fig 2. Section K.
H
G
...nison River
Fig 3. Section L.
F
E
...n River
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fault at the southern, I am unable to say. The western side of the cañon will have to be studied before the question can be decided.

Leaving the cañon the Gunnison keeps its westerly course for about six miles, when it makes some southing to the mouth of the Uncompahgre, which joins the river eight miles below the foot of the cañon.

The Uncompahgre is the largest tributary of the Gunnison from the south. It rises in the Uncompahgre Mountains (Sierra de la Plata of Gunnison*), and has a general course a few degrees west of north. The range in which it rises is one of the finest in the Rocky Mountains. The geology will be fully treated of in Dr. Endlich's report, the range being in the southern district. While we were in the valley of the Uncompahgre, we had a magnificent view of its snowy peaks, which stand out prominently against the sky. To the west we had a sight of the Sierra la Sal or Salt Mountains, the peaks being just visible.

Near the head of the Uncompahgre there seem to be some beautiful open parks. We did not visit them, as our trail led us up Cedar Creek, one of the eastern branches of the river. We were but a few miles above the mouth of Cedar Creek, at the point where the wagon-trail crosses.

Cedar Creek is probably dry during the greater part of the year. It rises in a plateau-like divide, opposite a small branch of Cebolla Creek, a few miles west of the mouth of the main stream. Its general course is about northwest. The upper portion of the valley is narrow and ravine-like, the slopes of the hills being covered with scrub-oak, sage, and cactus, with here and there patches of grass. This valley continues for about ten miles, when the creek comes out into the broad valley of the Uncompahgre, which at this point has lines of buttes of light-colored clayey-beds, the *debris* of which forms a soft soil, in which the mules sink to their fetlocks at every step. All the small creeks, dry for the greater part of the year, cut deep gullies in this soft soil, which is almost destitute of vegetation. In places there is considerable efflorescence of alkali, and gypsum is found abundantly throughout the valley. The buttes are found on the eastern side of the valley. They are from two hundred to four hundred feet high, and form two lines, those nearest the cañon of the Gunnison being the highest. The buttes are not so numerous in the lower part of the valley, where the general level is but a few feet above the river-bed. It is more plain-like, without grass, having only a sparse growth of low sage, interspersed with spots of alkali, giving the country a most desolate aspect. Along the river is an alluvial bottom, with good grass; the river being bordered with cottonwoods, willows, and low bushes of various kinds. This bottom becomes much wider as we descend, and is a favorite wintering place for the Ute Indians. We found traces of their camps, while their trails run in every direction. In one place we found a field where corn had been raised, the stalks of which were still standing.

On the opposite side of the Uncompahgre the country preserves a very uniform level for ten or fifteen miles to the west and southwest, where it seems to rise in a plateau. This level country is terraced, cut by the branches of the Gunnison and Uncompahgre, which contain water only in the spring. The terraces are for the greater part destitute of vegetation, being coverd with pebbles, among which are scattered fragments of chalcedony and agate. They are underlaid with Cretaceous strata, shales in the eastern part, and the sandstones of the Dakota group toward the west, as the country rises into the plateau. The

* Pacific Railroad Report, vol. ii, page 55.

latter was seen only from a distance, but it is probably similar to the country to the west of the Gunnison, near its mouth, the streams probably cutting through to the Triassic ? red sandstones. On the Uncompahgre the terrace is about one hundred feet high.

On the south side of the Gunnison below the mouth of the Uncompahgre, are three terraces. The first is 100 feet above the level of the river, the second 150 feet, and the third 200 feet.

Below the junction of the Uncompahgre, the Gunnison keeps a course a few degrees south of west, until it reaches the mouth of Roubideau's Creek, nearly five miles below. Here it enters the lower cañon. Above Roubideau's Creek the valley is very wide, averaging about two miles. The immediate river-bottom is also broad and overgrown with cottonwoods and low brush. There are numerous sloughs along the course of the river, and the fall per mile is very small. The river winds sluggishly in curves that sometimes seem to approach circles.

On the north side are terraces which soon form low hills or buttes reaching almost to the mesa. The edge of the mesa stands boldly out, like the edge of a fortification-wall. Its slopes are well timbered. The buttes below, extending toward the river, are composed of yellow, gray, and whitish strata, the weathering of which gives a most curious appearance to the landscape. On the south side, as I have already said, there are terraces extending southward toward the Uncompahgre Mountains.

The cañon which commences at the mouth of Roubideau's Creek, extends almost to the mouth of the Gunnison. It is, therefore, about 32 miles in length, in an air-line. By the Ute Indians it is called *Unaweep* or Red Cañon,* from the deep-red sandstones that are exposed at various points along its course. In the cañon the river winds considerably, and has in places meadows and even groves of cottonwood fringing it. It is not very rapid, the fall per mile being about eight feet. Although in an air-line the cañon is 32 miles long, the length of the river is about forty-five miles, or perhaps a little more, if we allow for all the smaller curves. The course of the river at first for ten miles is north 60° west. It then flows due north for about three miles, when it turns, taking a course to the northwest, which it keeps generally for nearly fifteen miles, when it again bends to the west and gradually curves back again to its mouth in the Grand.

The walls of the cañon often rise abruptly from the water's edge in sheer precipices, while in others there is a narrow strip between the river and the edge of the bluffs. The latter are better preserved on the eastern side, as the course of the river is nearly at right angles to the dip, which is approximately to the eastward, really a few degrees north of east.

At the mouth of Roubideau's Creek the walls are only 200 feet high, while at station 60 they are 663 feet high on the eastern side, and much higher opposite. This probably increases slightly as we go down-stream, but it can scarcely reach a thousand feet at any point.

At first the river merely cuts through the sandstones and shales of the Dakota group (Cretaceous No. 1), as shown in a section of the bluffs given in another portion of the report.

As we go down, the river gradually cuts through the base of No. 1 into the Jurassic shales and limestones; and finally, below station 62, the red sandstones (Triassic ?) appear beneath the shales.

Fig. 3, Plate IX, represents a section across the Gunnison through station 60 eastward to the mesa terminating the plateau divide. It will

* Vide Pacific Railroad Report, vol. II, page 57.

Plate IX.

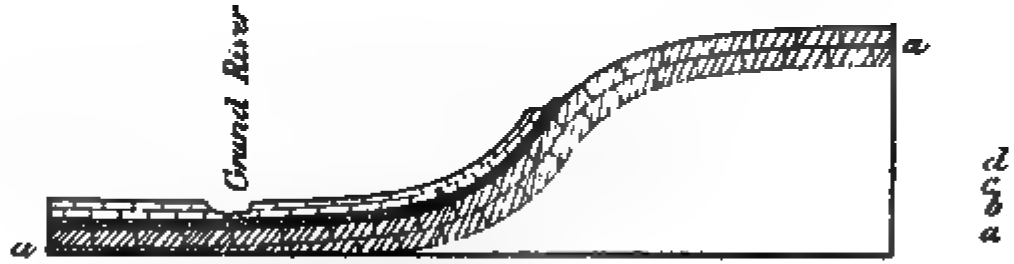

Fig 1

Fig 2.

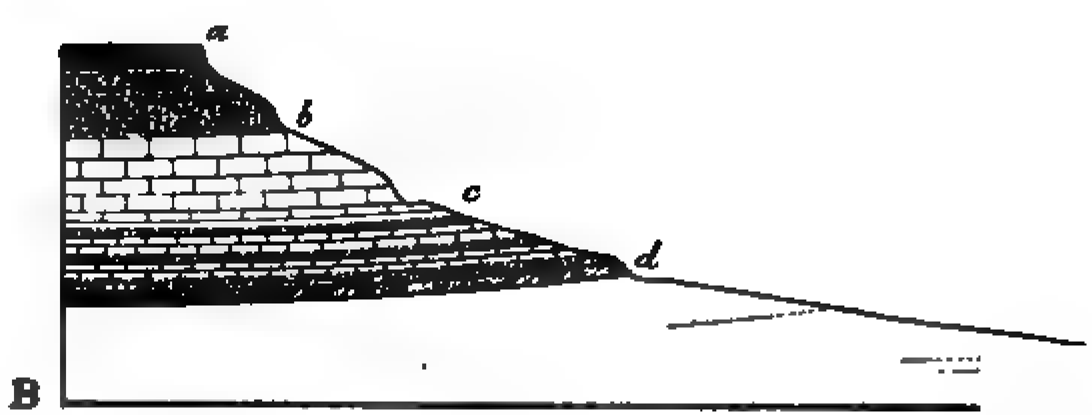

Fig 3. Section M.

be seen that there is a gentle slope from the edge of the cañon, and that from the edge of the mesa there is another slope, thus forming a valley between the two points. This valley is filled with Cretaceous sandstones, shales, and marls, which, on the east side, form mesa-like buttes.

There are five streams joining the Gunnison from the east in the cañon. The largest is Kahnah Creek. Most of the creeks cut deep cañons as they join the river. It will be seen, on referring to the illustration (Fig. 2, Plate IX), that there is a dip at right angles to the stream, and that this is the greatest at the river, and decreases as we go away in either direction. At the point where the section was made, the dip is only about 5°. Farther north, on the south side of the Grand, the angle is from 15° to 20°, decreasing as we go westward or southwestward to about 5°, and also decreasing as we go toward the east. There is therefore here a monoclinal fold, the axis of which has a direction about northwest, the dip being to northeast. At station 60, the fold is very gentle; but, as we have seen, to the north it is much steeper, and probably still farther it may become a fault.

Fig. 1, Plate IX, represents a profile of this fold as far north as we could see it from the mouth of the Gunnison. It will be in one of the districts during the next season, when it will be thoroughly investigated.

This cañon of the Gunnison seems, therefore, to have been outlined by a fissure in the rocks caused by their folding; otherwise it would seem most natural for the river to have cut its way through the soft strata that lie between the edge of the cañon and the basaltic-capped mesa.

The country to the southwest rises into a broad plateau, beyond which we could see the peaks of the Sierra la Sal. Red sandstones seem to form the basis of this plateau, which is cut into profound cañons by the branches joining the Gunnison on the southwest side. This will be in the field of explorations next season, and I therefore only refer to it here.

The bluffs of the Gunnison as we approach the Grand again fall off, and do not exceed 150 feet in height. A section at this point will be found elsewhere, with a description of the beds forming it.

CHAPTER IV.

STRATIGRAPHY—ARCHÆAN AREAS OF EAGLE, GRAND, AND GUNNISON RIVERS.

As will, perhaps, be evident from the preceding chapters, the greater portion of the country comprised in our district is underlaid with rocks of Tertiary and Cretaceous age, the older formations showing only where there are abrupt folds, and where the streams have cut through the more modern beds to them.

The other formations represented are the Jurassic, Triassic (?), Carboniferous, and Silurian. These will be referred to in subsequent chapters. The present chapter will be devoted to the consideration of the Archæan rocks, while separate chapters will be given to the sedimentary formations, and to the eruptive rocks of the district.

The Archæan areas are limited, and will be considered in the geographical order followed in the chapters on the general topographical and geological features of the district.

On account of the rapid and extended character of our explorations, and also the difficulty of getting at these rocks from their being cut into deep gorges by the streams, I am unable to present but few lithological details. As far as we were able to determine, the rocks are all metamorphic, dark micaceous schists prevailing. Until they are studied in more detail, their exact age must remain undetermined, although the occurrence of the Potsdam sandstone resting on them near the head of Eagle River, and at various localities in the district of 1873, proves them to be at least of Pre-Potsdam age. No facts were obtained in regard to their relations to the metamorphic series exposed in the Front range.

Eagle River.—The metamorphic rocks through which the upper tributaries of Eagle River cut their courses form the northern extension of the Archæan area of the Sawatch range. This area was described in last year's (1873) report, and therefore I will do little more than refer to it here. The group of peaks of which the Holy Cross Mountain forms one of the most prominent, marks the northern end of the great Sawatch anticlinal. The sedimentary beds curve gradually around the end of the range, the line of outcrop across which Eagle River cuts, on its way to the Grand being the direct prolongation of the line of outcrop crossing Frying-Pan Creek (noticed in the report for 1873, page 266).

The upper portion of the Eagle is for the most part in cañon cut in these rocks. The cañon is one mainly of erosion. As far as the sedimentary beds are concerned it is monoclinal. They, however, are not well shown until we reach the lower part of the cañon, which ends a short distance above the mouth of Roche-Moutonnée Creek.

This cañon, which has been partially described in a preceding portion of the report, is about two thousand feet deep, and presents all the peculiarities of gorges cut in gneissic or granitic rocks. The walls are steep and rugged, the river occupying the entire width of the cañon at the bottom. The trail keeps high up on the hills on the eastern side of the river.

I have already said that the cañon of Eagle River is due mainly to erosion. The course was probably determined by a line of fracture of which all evidence has been removed. There is no evidence of glacial action on Eagle River, although all the branches coming from the Sawatch range show it abundantly, especially Roche-Moutonnée Creek.

The valley of this creek is filled with masses of gneissic rock, beautifully rounded and smoothed by the glacier which once filled its valley.

Grand River.—A little more than three miles below the mouth of the Eagle, the Grand enters a cañon in which it is more than probable there are outcrops of metamorphic rocks, probable gneiss and schists. To verify this opinion the bottom of the cañon ought to be followed. The rocks at the entrance of the cañon are limestones, which from their position were supposed to be of Carboniferous age. The course of the river at this point is a few degrees south of west, while the limestones have a dip which in general is east. On the north side of the river it probably changes to south of east, and as we go up the creek that joins the Grand just above the cañon it changes more to the north. As we go down the cañon, therefore, the sedimentary beds rise and the Archæan rocks ought to be seen beneath. This opinion is confirmed by Mr. Marvine, in whose report this cañon will be fully described. He was on the northern side and had a much better opportunity to study its features.

He says that on comparing the thickness of the sedimentary rocks with the depth of the cañon it is evident that the gneiss must show beneath. The area, he thinks, is limited, for some five miles down the cañon there is either a fault or an abrupt fold which brings the sedimentary beds once more to the bottom of the cañon. With the exception of this exceedingly limited area, I believe there are no Archæan rocks shown along the course of the Grand, from the mouth of the Eagle to the mouth of the Gunnison.

Gunnison River.—The head of the Gunnison River is entirely in metamorphic rocks, which were described in the reports of last year. Below the mouth of East River, it flows through a belt of Cretaceous rocks, from which it again enters gneiss and schists, in which it keeps almost entirely from the mouth of Ohio Creek to the mouth of the North Fork. The only exceptions are where the river flows through broad, meadow-like valleys, and even here there are schists underlying the river-drift and alluvium. There are but few of these meadows, and all are above the Lake Fork of the Gunnison.

This belt of gneiss and schists is narrow for the most part, extending but a short distance from the edge of the river, except on the lateral branches where the metamorphic rocks are exposed some distance from the Gunnison, forming long, tongue-like areas. These lateral branches are generally in cañons, and the Gunnison itself cuts a cañon in the gneiss.

Below the cattle-camp near the mouth of Cochetopa Creek, the prevailing rocks on the south side of the Gunnison, for a distance of more than six miles, are schists and gneiss. Receding from the river, volcanic rocks will probably appear on top. On the north side, resting on the gneissic rocks, is a heavy layer of volcanic breccia, underlaid in places by sandstones, as evidenced by an outcrop not far below the cattle-camp. At station 71, the Archæan belt narrows, forming the walls of a cañon, through which the Gunnison winds with rather a tortuous course. A section from station 71 to the river is shown in Fig. 3, Plate XIV. On the opposite side of the river the rocks are identical. Immediately on the gneiss the sandstones rest, as shown in the illustration. They

are probably of Cretaceous age, belonging to No. 1 or Dakota group. The reason for this opinion will be given, at length, in a subsequent chapter. Farther down the river these sandstones increase in thickness, as shown in Fig. 1, Plate XIV, while the gneissic area is very narrow.

The presence of the Dakota group, resting immediately on the Archæan rocks, would seem to prove that in Pre-Cretaceous times this Archæan area was above sea-level. What its limits were I am unable to say. It was probably connected with the Sawatch range, a portion of which, as I mentioned in last year's report, was probably above the sea-level during Pre-Cretaceous times. There was a period of gradual subsidence. This commenced at least in Pre-Triassic ages; for, as shown in map B, as we approach Smith's Fork there appear, resting on the gneiss and underlying the Dakota group, first, beds of Jurassic age, and then the Red Beds (Triassic ?).

When the subsequent elevation began it is difficult to say, although it is altogether likely that it was Post-Cretaceous. It was probably gradual.

Erosion subsequently modified the original surface. Then followed the period when the breccia and lava was poured out, concealing the underlying formations. Between Lake Creek and Cebolla Creek, there are places where the schists and gneiss seem to be capped with trachytic rock, without any intervening layers; while at lower levels, on some of the small branches of Cebolla Creek, there are shales probably of Upper Cretaceous age, abutting immediately against the gneiss and horizontal in position. Near the mouth of Cebolla Creek the schists seem to dip to southeast. Here they are very coarse, with large masses of quartz and pink feldspar. The mica is silvery (probably *Muscovite*). The Grand cañon of the Gunnison in reality commences at the mouth of Lake Fork, although for nearly a mile it is not very deep. Below the mouth of Cebolla Creek, however, it is between 2,000 and 3,000 feet deep. The gneissic portion, opposite station 78, shown in Fig. 2, Plate VII, is 2,000 feet deep. The cañon extends to the mouth of the North Fork.

The Archæan area in which this cañon is cut is defined in map B, Fig. 2. Plate VII represents a section across it through stations 77 and 78, to Cedar Creek, on the line marked A B, on the map B. Fig. 1 in the same plate is a section on the line C D on the same map.

It will be noticed that the metamorphic rocks form a plateau like mass between the Gunnison River and Cedar Creek. This plateau narrows to the northwestward and ends in sharp, isolated peaks.

South of station 80 there is, however, as shown on the map, a narrow Archæan belt bordering the river, in which it cuts the deepest portion of its cañon. This belt extends to a point below the mouth of Smith's Fork and forms a bench on each side of the river, as seen in Fig. 1, Plate VII, at *a*. It will be seen in map B that the Gunnison River keeps on the eastern side of the plateau, and that on the west (Fig. 2, Plate VII, *h* to *i*), between it and Cedar Creek the strata are horizontal, abutting against the granitic rock. The age of these beds is probably Upper Cretaceous, while the sandstones under station 77, at *d* and *e* in Fig. 1, Plate VII, represent the Dakota group (No. 1) or a portion of it.

From the uniformity of level of the plateau it would appear that the sedimentary beds once extended over it and have been removed by erosion. In the section Fig. 2, Plate VII, they are shown on both sides of the river. If they once covered the plateau there must be a line of faulting along its western edge, for the level of the Upper Cretaceous beds shown there is below that of the Dakota group under station

77. Therefore the western side of the anticlinal fold must change to a fault.

If there is no fault, the force of upheaval must have been greater on the eastern side of the Archæan area. If this be so it would account for the fact that the Gunnison River keeps on the eastern side, as seen on the map. We would have to suppose, also, that a portion of the plateau formed an island in the Cretaceous sea. The western side of the plateau will have to be followed carefully before the exact relations can be determined. This I hope to do during next season. When we were in the Uncompahgre Valley it was late in the season; there was but little water, and, our supplies being reduced, we had to make forced marches, so that we were unable to finish the work on the western side of the cañon.

As already mentioned, the rest of the Archæan area on the Gunnison is very narrow. It is inaccessible in most places, and I am therefore obliged to pass by it with merely this reference. The remainder of the course of the Gunnison is in sedimentary formations, which will be referred to in their appropriate places.

It will be noticed from the foregoing pages that our district for 1874, unlike that of the preceding year, is entirely destitute of any metamorphic ranges. It is true that the metamorphic rocks on the Eagle River are a continuation of those in the Sawatch range; but this portion of the district forms the boundary, as it were, between the work of the two years. It was really within the limits of one of the districts for 1873, but was left unfinished. On the Gunnison and on the Grand, as we have seen, the metamorphic rocks are shown in cañons where the overlying formations have been cut through. In no other parts of the district are there any rocks of Archæan age.

CHAPTER V.

STRATIGRAPHY—PALEOZOIC FORMATIONS.

This chapter will be devoted to the Paleozoic areas of the district. They are as a rule few in number and of small extent. As in the case of the metamorphic rocks, the Paleozoic formations are found mainly along the courses of the great arteries of the district, never extending any great distance from them. They appear there outcropping beneath the rocks of Mesozoic age which cover a large part of the region. They have been identified principally by their position and lithological characters. Although frequent and careful search was made for fossils, it was generally without success. In Mr. Marvine's district organic remains were found in more abundance, especially in Carboniferous layers.

I shall take them up consecutively, commencing with the Silurian, and considering them in the geographical order adopted in the preceding chapters. On the Gunnison River no sedimentary formations older than the Red Beds (Triassic?) are seen. At no point in the district was I able to get the entire thickness of the Paleozoic strata. It is, however, probably about 4,800 feet.

SILURIAN AGE.

Although no fossils were found by me this year in the strata I shall refer to this age, still I think their position and lithological characters warrant such a reference. They rest immediately on the metamorphic rocks mentioned in the last chapter. We can say definitely that they are of a Pre-Carboniferous age. The upper portion of the series may at some future day, when more data are obtained, have to be considered as Devonian. Fossils of Carboniferous age were found in the layers resting immediately upon them. There was a much greater development in Mr. Marvine's district, and further details will be found in his report. In my district, the formation is limited to Eagle River with possibly a small area on the Grand.

I am unable to make any further division of the formation than to separate the Potsdam sandstone from the layers above, the base of the latter being referable to the Calciferous epoch or Quebec group. The entire thickness of the Silurian layers is about 820 feet.

PRIMORDIAL PERIOD—POTSDAM? GROUP.

The Potsdam sandstone is widely distributed in the Rocky Mountains, and preserves its characteristics in widely separated localities. Dr. Hayden noticed the strata in 1856 or 1857, in the Black Hills of Wyoming, and he and Professor Meek, in a paper read before the Academy of Natural Sciences, of Philadelphia,* announced the discovery of fossils,

* Proceedings Academy Natural Sciences, Philadelphia, March, 1858.

identifying them as belonging to the Potsdam group. Afterward Dr. Hayden found fossils in the same formation in the Big Horn range in Dakota. In 1869* he also found, near Colorado City, fossils in layers just above, that prove the layer in which they were found to belong to the Calciferous or to the Quebec group. In the report for 1870, he also mentions the group.

In 1872 Dr. Hayden and myself recognized the same group in Montana, near Gallatin City.† The same year Professor Bradley‡ recognized it in Utah, Idaho, and Wyoming.

Newberry§ speaks of the Potsdam sandstone occurring on the Colorado River in Utah. Comstock|| refers to it as occurring in the Wind River Mountains. In all these localities, the general characters are very similar. In Colorado, in 1873, I discovered Potsdam sandstone in various localities, but was unable to discover any organic remains in it, although just above, I found fossils referred by Professor Meek to the Quebec group. Dr. Endlich, in 1873, had outcrops of the group in his district, while the northern district was without any trace of it.

During the past season I found on Eagle River a series of beds resting on the gneiss and schists. From their position and lithological relations to corresponding beds found by me in 1873, I referred the lower layer to the Potsdam group. The characters of these beds will be given in the sections a little farther on. Their extent in my district was limited.

Eagle River.—The Potsdam group here is represented by a bed of white quartzite. Near the head of the river it is shown on both sides, dipping to the northeast at an angle of 5° to 10°. It is between 300 and 400 feet in thickness. As we go down the river it caps the ridge separating the two forks, while the gneissic rocks on the west side of the western fork are bare, the quartzite which once extended over them having been eroded away. Still farther along, opposite the cañon, they re-appear in patches, and soon extend from the edge of the cañon in long strips between the branches of the Eagle, toward the Sawatch range, as shown in Fig. 2, Plate I, representing the Potsdam sandstone on the gneiss. The inclination is toward the northeast, the angle being very small. At the point where the section in the illustration is made, it is shown on both sides, but as we go down the river it gradually disappears on the north, and appears only on the south side, where it continues to the southward, curving around the end of the Sawatch range. The inclination increases, and consequently the area occupied by the Potsdam becomes much narrower, connecting with the belt that extends across Frying-Pan Creek into the Elk Mountains.

Grand River.—The only place on the Grand where the Potsdam group is likely to be seen is in the cañon between the mouth of the Eagle and the mouth of Roaring Fork. Mr. Marvine's report will treat of this.

Gunnison River.—There is no exposure of this age on the Gunnison in our district for 1874.

CANADIAN PERIOD—CALCIFEROUS AND QUEBEC GROUPS.

Although I cannot define the limits of the groups, in ascending from the top of the Potsdam sandstone, I have thought it best to give them

* Report United States Geological Survey, 1870, page 259.
† Report United States Geological Survey, 1872, pages 72, 174.
‡ Report United States Geological Survey, 1872. Report of F. H. Bradley.
|| Ives's report of Colorado River; page 47 of Geological Report.
§ Report on Northwestern Wyoming, by William A. Jones, page 106.

a separate position here. Calciferous rocks were first recognized in the Rocky Mountains in 1869 and 1870. In 1869 Professor Hayden obtained fossils from near Colorado City, of which Professor Meek says, in the Report of 1870, page 287: "So far as these few fossils warrant the expression of an opinion respecting the age of the rock from which they were obtained, I should be inclined to place it nearly on a parallel with the Calciferous division of the Lower Silurian." Prof. F. H. Bradley, in 1872, recognized the Quebec group in Utah and Idaho. The series consisted of limestones underlaid by glauconitic sandstones. The limestones were mostly thin and contained interlaminated shales. The same year Dr. Hayden discovered beds of the same age in Montana, near Gallatin City. There we had layers of limestone also underlaid with glauconitic sandstones. In 1873 I found near Trout Creek, in Bergen Park, Colo., pink laminated limestones underlaid with glauconitic sandstones. In them I found fossils referred by Professor Meek to the Quebec group. Analogous beds had been seen in Glen Eyrie, where Professor Hayden, in 1869, found a few forms that were referred to the same group. I obtained a few indistinct fossils there in 1873. On Eagle River, above the white quartzite, that has been already treated of as belonging to the Potsdam group, we have glauconitic sandstones and quartzites that lie below a bluish limestone. No fossils were found here, and I refer the beds simply on the lithological evidence as in the following table:

	TROUT CREEK, 1873.	FOUR MILE CREEK, 1873.	EAGLE RIVER, 1873 AND 1874.
	Gneiss.	Gneiss.	Gneiss.
Primordial.	Yellow sandstone.	White quartzite.	White quartzite.
	Pinkish sandstone.	Reddish quartzite.	
Calciferous.	Dark purplish sandstone.	Quartzites with shales, glauconitic near the base.	Glauconitic sandstone.
	Green sandstone.		Quartzite.
	These beds are glauconitic.		Quartzitic conglomerate.
	Blood-red calcareous sandstone with *Lingulepis* and *Obolus*.	Blueish limestones with layer of quartzites near base, containing fragments of *Euomphalus* and *Orthis desmopleura*.	Light bluish limestone.
	Pink limestones, containing *Orthis desmopleura*, *Conocoryphe*, *Asaphus*, *Euomphalus*, *Lingula*, *Bathyurus*, and *Paradoxides* or *Olenus*.		

It will be observed that the order of the section on Trout Creek is observed in the other sections. Instead of sandstone, resting on the gneiss, we have quartzite, which in all of the sections is followed by beds which are glauconitic.

The limestones in the section on Four-mile Creek were considerably metamorphosed, and the fossils found, very indistinct. Still, those recognized identify the bed as belonging to the same horizon as the limestones in the section made on Trout Creek, which is of Calciferous age.

It may be that in the future the glauconitic beds will have to be de-

tached from the Calciferous group, and considered a part of the Potsdam. Not being able to define the boundary between the top of the series and the next succeeding group, I cannot give the thickness. The entire thickness of the Silurian will be given in another place.

Eagle River.—The Calciferous group is mainly shown on the east side of Eagle River, until a point below the cañon is reached, when it crosses to the other side. It does not extend up the slopes as the Potsdam group does, although patches of it may be found scattered over it. It is entirely conformable to the Potsdam group, and of course follows it across the country to the southward.

Grand River.—The only locality on Grand River, within our district, for 1874, where there is any probability of the group occurring, is in the cañon between Eagle River and Roaring Fork. The cañon was not followed by us, and therefore I cannot positively assert that it is shown there. The reasons for the opinion are given in the preceding chapter when speaking of the probability of metamorphic rocks appearing there.

Gunnison River.—The group occurs nowhere on the Gunnison River from the mouth of Ohio Creek to Grand River.

REMAINDER OF THE SILURIAN.

The remainder of the beds that I have included in the Silurian consist of limestones, which are for the most part magnesian. In one place on the eastern side of the cañon of Eagle River, there is just above these limestones a bed of trachytic-looking rock, 50 or 60 feet in thickness. I was unable to trace its extent, but farther north, between some higher layers, found a bed of similar rock, which was probably derived from the same source.

The following is the section of the Silurian strata, as exposed on Eagle River:

No. 1.—*Section of Silurian strata on Eagle River.*

Top.	Thickness. Ft.	In.
(?)		
7. Light-bluish limestones on weathered surfaces, white and yellow. It is in bands of from three to eight inches thickness, with a cross fracture and non-fossiliferous. A great portion of these limestones are probably magnesian. At the top they are crystalline	219	6
CALCIFEROUS GROUP:		
6. Space, in the upper portion of which there is an out-crop of metamorphosed conglomerate, seemingly composed of pieces of white quartzite and brown sandstone. The masses are irregularly shaped. The out-crop is only a few feet in thickness, and the remainder of the space is probably filled with sandstones and quartzites with perhaps a few shales. The space was so covered that the beds were all concealed. The entire thickness is	68	4
5. Milk-white quartzite, similar to that of No. 1	4	9
4. Space probably filled with sandstones	22	8
3. Grayish-brown laminated sandstones with a greenish coating and mud-marks on the surfaces of the laminæ	98	6
2. Fine-grained, rather compact, glauconitic sandstone, somewhat laminated, dark brown and greenish-gray	10	0
PRIMORDIAL GROUP:		
1. Milk-white quartzite	400	0
Gneiss.		
Total thickness Silurian about	819	9

It is probable that a portion of the limestone marked No. 6 in the section above, should be referred to the Trenton, or perhaps to the Niagara group. It is impossible to say whether No. 7 is all Upper Silurian or part Lower.

The following table gives the comparative thickness of the Silurian strata as noted up to the present time in Colorado:

Locality.	Thickness of Silurian in feet.
Glen Eyrie, on Camp Creek	113
Near Manitou, by Mr. Wm. H. Holmes	Maximum, 400
Trout Creek, in Bergen Park	150 to 250
In Park range	350
On Eagle River	820
North of Grand River, in Mr. Marvine's district	Maximum, 500
In Dr. Endlich's district, 1873	40 to 80

DEVONIAN AGE?

Dr. Endlich discovered a series of limestones in his district, in which there were characteristic Devonian fossils, and Mr. Marvine also obtained Devonian fossils in his district. While in the field I supposed the Devonian to be entirely wanting, and I have no positive data by which to define its limits in my district. Still there is the possibility of its presence; and if so, the limestones just above those given in the section of the Silurian will probably represent the formation. For the present, and until more reliable data can be obtained than I now have, I will include them in the section of the lower portion of the Carboniferous. They have a total thickness of over 1,000 feet. It is possible that the lower portion may be of Silurian age. I was unable to get a detailed section of them, so that all opinions are somewhat conjectural.

CARBONIFEROUS AGE.

Immediately above the limestones mentioned above, under the head of Devonian, is a series of strata having a blue fossiliferous limestone at the base, which is succeeded by sandstones and interlaminated shales varying from fine-grained and even-textured to coarse and conglomeritic layers. They are nearly all micaceous, and generally of a greenish-gray color, although in the lower portion they are red and pink. Some of the layers contain Carbonaceous material. From the fossils I discovered in the limestone at the base of these beds, and their lithological identity with the Carboniferous layers of the Park range as exposed on Four-Mile Creek,* I have referred the series to the Carboniferous horizon. It was impossible to define the boundary between the Carboniferous layers and those above, which are probably Permian, as the latter are comformable and form a continuous series, so I have arbitrarily chosen a line to separate them.

The Carboniferous formation was well developed in Mr. Marvine's district, and characteristic fossils were found by him in abundance. To his report the reader is therefore referred for more detailed information.

Eagle River.—On the Eastern branch of Eagle River above the cañon, and on the branch coming from the Blue River range, the formation is well developed. Unfortunately we did not have time to follow the streams, where we might have discovered many points of interest in regard to these beds.

East of the broad meadow on the eastern branch, above its cañon, Mr. Holmes, in 1873, found characteristic fossils, *Spirifer*, *Productus*, *Crinoids*, &c.

Below the cañon of the Eagle, opposite the mouth of Roche-Moutonnée Creek, the formation is well shown in the bluffs. It, however,

* Section No. 18, page 231, Report U. S. Geol. Survey for 1873.

soon crosses the river, as the underlying formations do, and extends to the southward into the district worked over in 1873. Its occurrence there was treated of in the report for that year.

A section of the strata on Eagle River, as shown in the bluffs, will be given in the section below. This section is compiled from two sections I made in 1873. A portion of the beds being exposed at the base of the bluff below the mouth of Roche-Moutonnée Creek, I had to make a section of the lower beds in the bluff above the mouth of the creek where they were exposed.

No. 2.—*Section of Carboniferous strata on Eagle River.*

Top.	Thickness. Ft.	In.
1. Pink conglomeritic sandstones	37	5
2. Conglomeritic sandstones and gray shales	92	9
3. Light-gray shales with hard sandstone bands	3	9
4. Blackish micaceous shales	3	9
5. Sandstones and interlaminated micaceous shales, some of the sandstones conglomeritic	367	2
6. Sandstone conglomerate with pebbles of quartz from one to two inches in diameter. This bed is the base of a bluff-like wall, and is 10 feet in thickness. Above are beds of shale and coarse sandstone in alternation. On top is a greenish micaceous sandstone	252	0
7. Coarse, grayish sandstone, with interlaminated shales; near the top is a layer of red sandstone, succeeded by a conglomeritic layer	25	1
8. Fine-grained, reddish-brown sandstone	27	4
9. Coarse-grained hard sandstone, spotted with green, general color gray..	4	0
10. White and greenish-gray conglomerates and shales. First we have a conglomeritic sandstone, and then green micaceous shales, with black carbonaceous layers; followed by more conglomeritic layers, above which is about 15 feet of hard sandstone, with interlaminated soft shales; then 5 feet of compact gray micaceous sandstone. Next are very soft greenish-gray micaceous shales, extending for about 10 feet, followed by from 10 to 12 feet of alternating shales and sandstone (some of the latter conglomeritic) in beds from 2 to 4 feet in thickness. Above these are conglomeritic sandstones with shales in the center. The total thickness is about	511	0
11. Coarse white sandstone, with a band of hard fine-grained sandstone near the top. The micaceous character is marked between the layers	40	0
12. White conglomeritic sandstone	5	0
13. Red conglomeritic sandstones	38	8
14. Dark-red micaceous shaly sandstones	6	8
15. Brownish-red sandstones, conglomeritic	30	10
16. Fine-grained sandstone, generally white, but becoming pink in places, with two or three layers of gray micaceous shale, each from two to four inches thickness	4	0
17. Coarse white sandstone, with grains of quartz and some decomposed feldspar	71	3
18. Soft greenish sandstone in fine layers, with a few hard bands, each a few inches in thickness	99	3
19. Red sandstone	11	4
20. Brownish sandstones	99	8
21. White granular brown-spotted sandstone	8	0
22. Greenish-gray micaceous sandstones, partially conglomeritic	352	0
23. A space in which the beds were so much concealed that it was impossible to make a detailed section; the upper portion is probably filled with a prolongation downward of the micaceous shales and sandstones, while the base is limestone. In the latter I found *Aviculopecten*, *Pleurophorus*, and an *Avicula* or *Bakevellia*. The total thickness of strata as indicated by the space is	408	4
Total thickness of supposed Carboniferous	2,504	20

The remainder of the section to the beds I included in the Devonian? is as follows:

24. A laminated trachytic rock	15 feet.
25. Space probably filled mainly by limestones	1,000 to 1,500 feet, estimated.
26. Black flinty limestone, with pieces of pyrite and fragments of *Spirifer* or *Spiriferina*	

Under the head of Devonian, I referred to these beds, and said that they occupied debatable ground. A portion of the upper limestone may have to be referred to the Lower Carboniferous, while the lower layers may be of Silurian age, leaving the center to represent the Devonian. Of course, without fossils to prove their age, all opinions are merely conjectures.

The section given above holds good in detail only for the locality in which it was made. The beds are very irregular in their horizontal extension, some of them thinning out very rapidly. Thus, for instance, the bed numbered 17 in the section above, in another place, not more than half a mile distant, was only three feet in thickness, instead of seventy-one. One of the illustrations in last year's (1873) report * shows this remarkably well. Not only do they thin out, but they also change in color and nature, as we trace them. A bed of red sandstone will gradually fade into white, while a layer that is fine-grained in one place will become conglomeritic as we follow it horizontally. The space containing beds numbered in the section from 18 to 22, inclusive, in another place is occupied by light-red conglomerate sandstones, with interlaminated dark-red shales. Above the section is a thickness of about 1,300 feet of strata, to which I will refer when I speak of the Permian. The lower portion might be referred to the Upper Carboniferous, but as there was nothing to mark the end of the Carboniferous or the beginning, I have arbitrarily separated them.

Below the second cañon of the Eagle are outcrops of gypsiferous beds, to which I will refer under the head of Permian. None of the limestones or sandstones, referred to above, outcrop until we reach the Grand below the mouth of the Eagle.

Grand River.—The rocks forming the entrance to the cañon of the Grand River, that extends from a short distance below Eagle River to the mouth of Roaring Fork, are limestones, probably of Lower Carboniferous age. They also form a small cañon on the creek that joins the Grand at this point. Above, the valley of the creek widens, and succeeding the limestones are sandstones forming bluffs, especially on the eastern side. Farther up the creek the gypsiferous series forms the top of the bluffs.

The following section was made about a mile and a half above the mouth of the creek:

No. 3.—*Section on branch of Grand River.*

Base.	Thickness. Ft.	In.
1. Occasional outcrops of coarse gray sandstones, with interlaminated greenish shales. The space in which they occur extends from the base of the bluff	150	0
2. Fine black shales, breaking into very fine laminæ	36	0
3. Coarse conglomeritic white sandstone, in beds of from three to five feet thickness, with interlaminated soft greenish shales, in bands from two to three feet thickness	41	0
4. Very hard, compact, dark, greenish-gray sandstone	32	9
5. Coarse white conglomeritic sandstone	16	4
6. Hard gray sandstone, in bands of about a foot thickness each, with interlaminated greenish shales	49	1
7. Bluish calcareous sandstone, with their bands of shaly limestone	45	0
8. Coarse gray conglomeritic sandstone	2	0
9. Massive yellow sandstones, with bands of fine black shales. These beds are gypsiferous at the base. They form at the point where the section the top of the bluff. Thickness about	200 or 300 feet.	
Total thickness	579 - 679 feet.	

* Fig. 15, opposite page 71, Report United States Geological Survey, 1873.

The strata exposed in the cañon of the Grand will be treated of in Mr. Marvine's report, to which the reader is referred.

Gunnison River.—Nothing was found along the course of the Gunnison River that could be referred to the Carboniferous.

In treating of the Carboniferous formation as exposed in our district, up to this point I have made no division. I have not separated the Subcarboniferous from the Coal-Measures because I had no reliable data to guide me in making such a separation. I believe, however, that the limestone which lies at the base of the section made on Eagle River represents the Subcarboniferous, although I cannot say so positively, and that the sandstone and shales which overlie it conformably are the representatives of the Coal-Measures of the eastern portion of the United States. As exposed in the bluffs on the eastern side of Eagle River, these sandstones and shales have black coaly-looking layers between them, while patches of black carbonaceous material are of frequent occurrence in the midst of the sandstones. During their deposition there must have been, on Eagle River at least, low marshy ground which probably extended around the Sawatch range.

The beds on *a* creek (Map A) present the same general characters as those on Eagle River, and belong in all probability to the same horizon, although without the discovery of organic remains this cannot be positively asserted. The strata in their horizontal extension, as already mentioned, change rapidly, so that lithological characters are very uncertain tests of age.

PERMIAN OR PERMO-CARBONIFEROUS.

Under the head of Permian, I will describe the strata that continue uninterruptedly from the top of the section given under the Carboniferous, to the base of the Red Beds, (Triassic?)

I have called them Permian, from the discovery in the beds on Eagle River of fossils which Professor Lesquereux decided were of Permian age. On Eagle River, on the Grand and on Roaring Fork the upper portion of these beds is exposed, and in all these localities the beds are gypsiferous. They consist of variegated strata, yellow, pink, and cream-colored shales and limestone, subject to so much change that it was impossible to make any continuous section.

Dr. Hayden found a series of beds in the Black Hills which he referred to the Permian, as they contained fossils that had been before found in Kansas and referred to the Permian.

Below the series in Kansas is another set of beds which were also referred to the Permian by Swallow and Hawn, but which have been referred by Meek and Hayden* to the Upper Coal-Measures. Between, however, is a series to which they gave the name of Permo-Carboniferous. Professor Meek says:† "This latter distinction, however, it should be remembered, is, as we have always explained, even in Kansas, merely an arbitrary one, not founded upon any well-defined physical or paleontological break between these upper beds and the Upper Coal Measures."

On Eagle River, also, as I have before said, there is no break between the Carboniferous and the Permian.

In New Mexico, Shumard claims to have found Permian strata in the Guadalupe Mountains.

* United States Geological Survey, Final Report on Nebraska.
† Ibid, page 130.

Eagle River.—The remainder of the section made in bluffs on Eagle River near the mouth of Roche-Moutonnée Creek is as follows:

No. 4.—*Section of Permian or Permo-Carboniferous strata on Eagle River.*

Base.	Thickness. Ft.	In.
1. Coarse white conglomerate	27	3
2. Greenish-gray micaceous sandstone shales, with bands of very hard sandstone	45	11
3. Very hard irregular-structured blue limestone, of a brownish color on weathered surface	10	0
4. Coarse gray sandstone with interlaminated shales	145	6
5. Massive sandstones, generally of a gray color, with a greenish tinge. They are mostly fine-grained and generally micaceous. Some of the beds are pebbly, and near the bottom is a band of black shale with carbonaceous material. This band is from six to eight feet in thickness. These sandstones are exposed in a bluff in the upper part of which they are conglomeritic and darker in color than below	205	10
6. Rather coarse gray sandstones, in thin beds, fossiliferous, and weathering of a rusty color	342	4
7. Space probably filled with sandstones and shales reaching to the summit of the hill back from the bluffs, containing a thickness of about	500	0
Total thickness about	1,276	4

This probably does not represent the entire thickness of the beds, as I was unable to carry the section up to the base of the Red Beds, and, farther down Eagle River, where the Red Beds are present, the strata immediately beneath are so changed that I could not positively recognize any of the beds of the section made farther up the river.

In bed No. 6 of the section, in 1873, I found fossils which Professor Lesquereux identified as *Calamites suckovii*, Brgt., *Stigmaria fucoides*, and *Calamites gigas*, Brgt. I quote his remarks from my report of last year. Of *Calamites suckovii* he says: "This species is perhaps more abundant in the Coal-Measures; but it ascends to the base of the Permian, where in Europe, at least, it has been found in plenty." The species was, however, associated with *Calamites gigas*, which Professor Lesquereux says "is exclusively Permian and has never as yet been found in the Carboniferous Measures." Of *Stigmaria fucoides* he says "it is a universal species of the Coal-Measures also ascending, rarely, however, to the base of the Permian. I am inclined to consider it as Permian, merely by the lithological relations to the other specimens, but it is not possible to decide positively from this."

I think it probable, therefore, that the lower layers in the section given above may be of Permo-Carboniferous age, as there is but one species that belongs exclusively to the Permian, while all above should probably be referred to the Permian.

In contributions to the fossil flora of the western Territories, Part 1 (vol. vi, Report United States Geological Survey), Professor Lesquereux says (page 15): "In the explorations of Dr. Hayden, 1873, however, Dr. A. C. Peale discovered, in strata referred by him either to the Carboniferous or the Permian, a number of well-preserved branches or stems of *Calamites*, whose identification proves for the formation whence they are derived the same intermixture of characters referable to both the Permian and Carboniferous." "This coincidence in the data furnished by animal and vegetable paleontology, (*referring to some remarks given upon this statement*,) proves that the end of the Paleozoic times in our American geology is marked from the Mississippi River to the Rocky Mountains by the Upper Carboniferous, already modified by the first traces of Permian life." Professor Lesquereux, however, says that the Dakota

group is in immediate superposition to this Upper Carboniferous. This is probably a mistake, as we will see further on. In going down Eagle River we find that these layers, like those of the lower formation, cross the river and are shown on the western side. From the mouth of the Piney to the head of the second cañon of the Eagle, the prevailing rocks on the hills bordering the valley on either side, are probably of Permian age. On the eastern side the Red Beds (Trias?) show above them on the summits of the hills, which are comparatively low and rounded. On the western side the Red Beds do not appear until we reach the head of the cañon. The beds here that I have referred to the Permian consist of a series of gypsiferous beds, shales, and sandstones, with probably a few bands of limestone. I was unable to make any section of them.

Dr. Hayden, in the report for 1873, refers them all to the Carboniferous, finding species of *Productus* and *Spirifer* in the lower part of the series, and in the upper part a specimen of *Orbicula*. I have given my reasons for calling, at least the upper portion, Permo-Carboniferous, and Professor Lesquereux has shown that Carboniferous forms are mingled with Permian in the fossils I collected on Eagle River. In Mr. Marvine's district the gypsiferous beds extended down into the Carboniferous.

Above the cañon on the west or south side of the river the area occupied by the gypsiferous series extends some distance back from the edge of the valley. At the head of the cañon on the west side the dip is south 80° west. The strata cross the river, conforming to the overlying Triassic and Cretaceous layers which make the spoon-shaped curve that is represented in Plate II, and which has already been referred to. The angle of inclination at this point is 60°. This, of course, diminishes as the strike turns and is parallel to the course of the river.

The following is a general section at this point:

No. 5.—*Section of Permo-Carboniferous.*

	Feet.
1. Gypsiferous shales and sandstones. The gypsum occurs in great quantity and is rather impure. The sandstones are laminated and generally of a pink or red color. I was unable to get the exact thickness, but the outcrop was from	500 to 800
2. Shales, sandstones and limestones, alternating colors, pink, brown, gray, yellow, white, cream color, and blackish. These beds are best shown on the north side of the river. They incline generally about 60°. In some places they are inclined past the vertical, especially in the upper portion. The thickness is about	500
3. Pink, brown, and gray shaly sandstones with interlaminated thin beds of blue limestone. These beds resemble those I noticed in 1873 in South Park, which are given in the report of 1873, in sections 9, 10, and 11. The thickness on Eagle River is about	200
Total thickness	1,500

The gypsiferous series is probably tipped up with the overlying beds, as represented in Fig. 1, Plate I, at *e*, although they are hidden by the volcanic overflow. Below the cañon they occupy the greater part of the valley. This area is indicated on the map A. It is difficult here to reduce the strata to any order. Their softness has caused them to yield readily to eroding influences, and they have weathered into low hills, in which they are for the most part concealed. There are one or two folds in them of some extent. These I referred to in the chapter on Eagle River Valley. Besides, however, there are numerous minor foldings, which it would require more time than we could give to reduce them to any system. Mr. Marvine will probably have some additional notes, as they extended into his district.

The sections in Plate III show the gypsiferous series below the Red Beds at the points marked *a*. They are probably the same beds I noticed last year* on Frying-Pan Creek, above shales and sandstones that I then referred to Carboniferous. I did not know exactly where to put the gypsiferous beds, whether to include them with the Red Beds which were exposed in the hills above or to place them with the Carboniferous.

In the lower cañon of the Eagle, which extends to the mouth, the gypsiferous beds are well exposed, dipping from the river on both sides, leaving the channel in the axis of the anticlinal. Near the mouth of the river a flow of lava from the hills on the eastern side has forced the river to the opposite side, and it has scooped out a large portion of these soft beds. The Red Beds here cap the bluffs on either side.

Grand River.—The gypsiferous beds continue from Eagle River to the Grand, and follow it to within a short distance of the cañon, when the line crosses to the southwest and appears again on a creek, at first only capping the bluffs on the east side, but gradually showing in the bed of the creek as we ascend. They do not appear again until we cross to Roaring Fork, where they show beneath the Red Beds of the hog-backs that extend along the western side of the creek, below Rock Creek. They are represented at *d* in Fig. 2, Plate IV. At first the series is seen only on the western side of Roaring Fork, but as we go down they gradually appear on the eastern side, also extending up a small branch that comes in from the east. On the western side, at first they have a terrace-like surface. Further down they form bluffs, on the sides of which they weather into pinnacles and spires of yellow and pink colors. They continue to the Grand, where the Red Beds appear above them on the south side, and on both sides of Roaring Fork. Below the mouth of Roaring Fork the gypsiferous beds cross the river into Mr. Marvine's district. In Fig. 1, Plate IV, they are shown at the point *e* to *f* in the section on the north side of the Grand.

Gunnison River.—The gypsiferous series does not show anywhere on the course of the Gunnison or its tributaries in our district.

* Report of United States Survey for 1873, page 266.

CHAPTER VI.

STRATIGRAPHY—MESOZOIC FORMATIONS.

The Mesozoic formations in our district are divided about as follows:

	Thickness in feet.
Triassic	1,000 to 1,500
Jurassic	400 to 900
Cretaceous	4,000 to 4,700
	5,400 to 7,100

In the Triassic beds the arenaceous element seems to predominate, a few bands of limestone appearing in the Jurassic. Sandstones and marls prevail in the Dakota group. In the rest of the Cretaceous, shales form the largest portion of the strata, alternating with sandstones and thin bands of bluish limestone.

The red sandstones of the Trias (?), in the eastern part of the district have a more laminated structure than was noticed either in the Front range in 1873, or in the Gunnison this year. Cretaceous strata cover larger areas than any of the underlying strata, as will be noticed as we proceed.

TRIASSIC.

Although the red sandstones which are referred to the Triassic form a well-defined lithological series, and are prominently exposed over the Rocky Mountains and at widely-separated localities, with very little change, less is, perhaps, definitely known in regard to their age than of any of the sedimentary formations of the West.

The correctness of the assumption of Triassic age for them depends entirely upon their position. Up to the present time no fossils have been found in them. The character of the sandstones is not favorable to the preservation of organic remains.

They have been referred to the Triassic by Marcou, Newberry, Hayden, and others who have studied them in the West.

In the Black Hills and at Red Buttes, on the North Platte, in Wyoming Territory, they underlie well-defined Jurassic layers, as determined by Dr. Hayden. In Colorado, also, they are beneath Jurassic layers, along the eastern edge of the Front range. Near Pleasant Park, in 1873, I found Carboniferous fossils* in a series of red limestones and calcareous sandstones. These beds were beneath the red sandstones. Again, as already mentioned in the preceding chapter, I found fossils of Permian age below the Red Beds, so that they must be referred either to the Permian or to the Jurassic, leaving an unoccupied gap between. Therefore, until fossils are found by which their age can be definitely settled, I think it best to refer them to the Triassic.

The line between the Triassic and the Jurassic is indefinite, and I

* Report United States Geological Survey, 1873, page 198.

have taken the upper or more massive part of the sandstones as the limit of the Triassic formation, referring all above to the Jurassic. This arbitrary division was also used by Mr. Marvine last year.

As already mentioned, these red sandstones vary but little over broad areas. On the Colorado River they were observed by Newberry.* In Colorado, last year, we had them in the Front range, in South Park, and in the Elk Mountains, and they were readily recognized by their lithological characters. Their general massiveness was a prominent characteristic.

Eagle River.—Near the head of Eagle River the Red Beds do not appear close to the river, although they are doubtless exposed between the Blue River range and Eagle River. Below the Piney they outcrop in the hills bordering the valley on the east. The strike here is parallel, or nearly so, with the course of the river. At the head of the second cañon, however, the line of outcrop crosses the river almost at right angles to its course, first making a spoon-like curve shown in the illustration in Plate II. On the south side of the river it curves to the westward, and then gradually to the north, crossing the river again at the foot of the cañon, as shown on the map, (A,) and extending up into Mr. Marvine's district. Opposite the cañon, that is, south of it, this curve forms the northern side of an anticlinal fold or break, which is shown in Fig. 1, Plate I, caused by the protrusion of the trachytic mass shown in the illustration.

A section of the Red Beds, as exposed near the Eagle River, on the south side, is given below.

No. 6.—*Section of Triassic on Eagle River at second cañon.*

Base.	Thickness. Feet.
1. Red sandstones, somewhat laminated	70
2. Purplish sandstones	15
3. Red and brown laminated sandstones, some of the layers being seemingly calcareous	193
4. Coarse white sandstone	5
5. Red sandstones, more massive than the lower layers, although there is some lamination	375
6. Pink quartzitic sandstone }	300
7. Red sandstones somewhat laminated }	
8. Massive light-colored quartzitic sandstone	10 to 20
Total thickness	978

It will be noticed in this section that there is considerable lamination in the red sandstones. Farther westward this lamination is not so decided.

Below the cañon, in the hills that rise back of the low gypsiferous hills, the Red Beds form the surface, covering a large area, extending across to Frying-Pan Creek. They form broad-topped ridges, in which the general dip is toward the north, the inclination being slight. As we approach the valley of the Eagle, however, it increases and we have several folds, as pointed out in the chapter on Eagle River Valley.

On station No. 8, the red sandstones dip a few degrees east of north. On station No. 9, they dip North 35° West, angle 30°–35°.

I have already spoken of the probability of there being here a synclinal fold, of which the eastern half has been removed. This fold is indicated in the illustration Fig. 1, Plate III, by the dotted lines. Below the valley, the river flows through a cañon-like valley in the axis of an

* Ives's Colorado Exploring Expedition, Geological Report.

anticlinal, which is shown at *a a* in Fig. 1, Plate III, the Red Beds forming the top of the bluffs on either side of the river, as shown in the figure.

Grand River.—From the mouth of Eagle River the Red Beds cap the bluff for some distance, when the line of outcrop crosses to the southward and afterward to the east, joining the line continuing westward from *h* creek (map A), thus forming an isolated area of red sandstones. Between the Grand and Roaring Fork, there is another patch of Red Beds, which is partially concealed by an overflow of lava. On the west side of Roaring Fork we have the Red Beds showing in the hog backs. Their thickness here is about 1,500 feet. They dip south 75° west, at an angle of 30°, below station 14. The upper part of the series here has layers of pink conglomerate sandstone.

As we go down Roaring Fork the strike curves to the westward, and the Red Beds disappear beneath a layer of volcanic rock which covers the hills here. They re-appear on Grand River on the south side, a short distance below the mouth of Roaring Fork, forming high bluffs, that rise 500 or 600 feet above the level of the river. The Grand then gradually cuts into the red sandstones, following the strike, which is about north 60° west for nearly four miles in an air-line, forming the base of the hog-backs that here extend along the southern side of the Grand. The river then cuts across the strata, flowing out into higher and softer beds, while the Red Beds cross into Mr. Marvine's district. From this point to the mouth of the Gunnison there are no exposures of the Triassic sandstones.

Gunnison River.—The Triassic sandstones do not appear on the Gunnison River until the lower half of the Grand Cañon is reached. They seem to increase gradually in thickness, although the total thickness attained in the cañon is not very great. They rest immediately on the granite shelf forming the edge of the cañon below station No. 80. The area occupied by them along this cañon is indicated on map B. At station 80, the anticlinal axis occupied by the river is very evident. It is shown in Fig. 1, Plate VII, at *a*. Leaving the cañon the river cuts across the northern end of the anticlinal, and, turning to west, flows out into the soft shales of Cretaceous age. In the second or lower cañon the river cuts down through the Dakota group and the Jurassic layers, and partially into the Red Beds.

The top of the series here is a pink sandstone, from 30 to 40 feet in thickness. The thickness of the red sandstones varies. Below station 60, where the pink sandstones were measured, the thickness exposed is about 150 feet. They are massive and present all the characteristics that the Red Beds east of the mountains do. They dip approximately to the eastward, the angle decreasing as we leave the river and increasing to the west. The river winds through the cañon in large curves that almost meet each other. Whenever the curve is to the westward the red sandstones are cut into most deeply, and when the curve is in the opposite direction the Red Beds, if exposed at all, are only cut into slightly. This causes the areas of Triassic age to appear in patches along the course of the river. All the streams joining the Gunnison from the west cut profoundly into the strata, and near their sources, may have outcrops of Pre-Triassic layers along their courses. I have already referred to the fact that the Gunnison River at this point follows a rift or break, which was probably caused by a monoclinal fold. Two sections across this are shown in Figs. 1 and 2, in Plate IX. At first the fold as shown in Fig. 1 is not very marked. It gradually increases, however, and below the mouth of the Gunnison is as repre-

sented in Fig. 2. Farther on this fold probably becomes a fault. In the two figures just referred to, the red sandstones are represented at *a*.

To the west and southwest of the Gunnison the red sandstones seem to prevail extensively, and probably from the top of the plateau which, as seen from the Gunnison, extends in this direction. The Indians give the lower cañon of the Gunnison the name of *Unaweep* or Red Earth, evidently on account of the exposures of Red Beds along the edge of the river.

JURASSIC.

Immediately above the Red Beds, between them and the Dakota group, is a series of sandstones, marls, and limestones which I have referred to the Jurassic, although I was unable to find any fossils at any point where they were exposed in our district of 1874.

They correspond lithologically and stratigraphically to the strata that in 1873 I referred to that horizon. The reasons for so doing were stated in the report for 1873, and I will not take up the space here with the repetition of them. They are generally in thin beds, the shaly element predominating. Their softness has rendered them readily amenable to eroding influences, so that they are generally covered with *débris*, and it is difficult to make complete sections of the formation.

The Jurassic formation is widely spread in the Rocky Mountains, its distribution being identical with that of the Dakota group and the underlying Red Beds. Hayden, Newberry, Comstock, and others have recognized it in various portions of the West. Marcou* also claims to have discovered it in New Mexico and other parts of the West, but, as I shall subsequently point out, the layers referred by him to this horizon are probably of Cretaceous age, while those that are Jurassic he refers to the upper part of the Triassic.

Dr. Hayden†, speaking of the formation, says: "At both of these localities (*near the Wind River Valley and Big Horn Mountains*), at the Black Hills and at the Red Butte on the North Platte, as well as at the other localities already mentioned in Utah (*near Uintah and Weber Rivers*), the rocks containing these Jurassic fossils consist of a series of grayish, ash-colored and red argillo-calcareous, more or less gritty strata, with beds of soft dark-brown and reddish sandstones. These beds preserve a remarkable uniformity of character taken as a group, wherever they have been seen, and need never be confounded with the Cretaceous or Tertiary rocks so widely distributed over the Northwestern Territories, even where no fossils are to be found."

In Colorado, Dr. Hayden, Mr. Marvine, Dr. Endlich, and myself found the Jurassic layers presenting the same general characters that they do north of the Union Pacific Railroad. Along the eastern edge of the mountains in Colorado, the greatest thickness measured was 870 feet.

Eagle River.—On the south side of the river no strata of Jurassic age appear until we reach the head of the second cañon, when it crosses from Mr. Marvine's district conformable with the overlying Cretaceous, and underlying Triassic.

The following is a section made on the south side of the river at the point where the section previously given of the Triassic sandstones was made.

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*Geology of North America, by Jules Marcou.

†Geological Report of Exploration of the Yellowstone and Missouri Rivers. F. V. Hayden, under Capt. W. F. Raynolds, 1859–'60.

No. 7.—*Section of Jurassic, head of second cañon, Eagle River, south side.*

Top.	Thickness in feet.
1. Space probably filled with sandstones and marls, about	500
2. Laminated sandstones and blue limestone	} 190
3. Light-yellowish brown sandstone	}
4. Blue limestone	50
5. Gray shaly sandstones with interlaminated marls and thin bands of blue limestone	200
Base.	
Total about	940

A portion of these bids may be Cretaceous.

Nowhere along the course of the Eagle, nor at any point in the district, does the Jurassic formation occupy any extensive area. It occurs only as a narrow belt outcropping beneath the Dakota group. It is, therefore, shown principally along the courses of the streams.

The line of outcrop on which the section given above was made continues conformable with the Cretaceous and Triassic strata, following the curve indicated on the map, and crosses to the north side of the Eagle at the lower end of the cañon.

Around the almost circular area of Cretaceous rocks south of the Eagle, represented on the map, there is, in all probability, a narrow belt of Jurassic, although I cannot be positive, as I have not followed it around, and judge so only from my observations from stations 6 and 8. With this exception, I believe there are no Jurassic strata exposed between the Eagle and Frying-Pan Creek. In the low, rounded hills which occupy the greater portion of this space, all the beds above the Triassic sandstones have been removed.

Grand River.—From the mouth of the Eagle to the mouth of Roaring Fork there are no exposures of Jurassic age close to the Grand. The Red Beds here form the top of the stratified rocks and are covered with a volcanic layer. There may be an occasional outcrop between the head of *a* creek of Grand River and Roaring Fork. If so, they must be very limited in extent. At the head of Mesa Creek, a branch of Roaring Fork, there is probably a narrow belt dipping to the south or southeast.

In the hog-backs, on the west side of Roaring Fork, the Jurassic strata are seen following the line of the overlying and underlying strata, disappearing beneath the volcanic rock capping the hills, and re-appearing on the Grand below the mouth of Roaring Fork, finally crossing the Grand, and extending to the northwest, forming a portion of the hog-back range, that dies away in the plateau. Between this point and the mouth of the Gunnison there are no other exposures of Jurassic age along the course of the Grand.

No. 8.—*Section of Jurassic, west side of Roaring Fork, below station No. 14.*

Base.	Thickness in feet.
1. Coarse gray sandstone	20 to 30
2. Space probably filled with sandstones and shales	20
3. Fine-textured light-yellowish sandstones	15
4. Space probably filled with sandstones, marls, and shales, and perhaps some limestones	165
5. Light-colored fine-grained siliceous sandstone	30
6. Soft shaly sandstone, probably slightly argillaceous	12
7. Blue limestone	8
8. Gray sandstones, becoming greenish near the upper part	125
9. Dark-brownish gray sandstone, becoming lighter as we ascend	15
10 Brownish sandstone with interlaminated black shales	20
Top.	
Total about	440

Just above the bed marked No. 10 in the section is a massive sandstone, from 60 to 70 feet thick, which forms the summit of a prominent hog-back, beyond which the beds are concealed. I have taken this bed as the lower portion of the Dakota group. It is possible that on further investigation the layers marked 8, 9, and 10 may have to be included in the Dakota group. This would give a total thickness for the Jurassic at this point 280 feet instead of 440 feet.

Below the first layer in the section is a coarse pink sandstone, which at some points is a conglomerate. It rests immediately on the red sandstones, and I have taken it as the top of the Triassic. Of course, without the evidence of fossils, the lines separating the Jurassic from the Cretaceous and the Triassic must be necessarily, somewhat indefinite. The lines I have taken are therefore arbitrary and liable to be changed when more complete data are obtained.

In the section given above, and in that made on Eagle River, it will be noticed that the arenaceous element seems to predominate. The beds were so much concealed that it was impossible to make a more detailed section. The extension of the hog-backs up Rock Creek into the Elk Mountains will be treated of in the reports of Dr. Hayden and Mr. W. H. Holmes.

Gunnison River.—The Jurassic appears on the Gunnison first in the Grand Cañon, resting immediately on the schists, and gradually becoming thicker as we go down the river, until the Red Beds appear between it and the schists. The Jurassic is also exposed on Smith's Fork, extending some distance from the mouth up the stream.

The area occupied by the formation, in connection with the Red Beds, is shown on map B.

I was unable to make any section in the course of the cañon, but, as seen from station No. 80, it appears to consist of variegated yellow, white, pink, and gray beds, probably sandstones, shales, and marls. On the eastern side of the cañon these beds have a much greater extension than on the west. The entire thickness is probably about the same as in the lower cañon, as shown in the section to be given farther on.

On Smith's Fork, the variegated appearance of the Jurassic strata is also seen. In the sections made on Eagle River and Roaring Fork, this is wanting. I shall refer to this fact again. In the lower cañon the Gunnison very soon cuts through the Dakota group, which, at the head of the cañon, forms the bluffs on either side, and reaches the soft Jurassic layers beneath.

At first they are exposed in isolated patches similar to the outcrops of the Red Beds lower down, varying according to the curves of the river. When the Red Beds are reached, however, the Jurassic is shown on both sides of the stream.

No. 9.—*Section of Jurassic in the lower cañon of Gunnison River near Station* 60.

Base.	Thickness. Ft.	In.
1. Soft greenish and purplish argillaceous sandstones about	20	0
2. Space filled with gray laminated limestones and interlaminated soft gypsiferous shales	80 to 90	0
3. Compact white siliceous sandstone	8	9
4. Soft argillaceous and arenaceous shales, with bands of hard sandstone from 6 inches to a foot in thickness. The shales are covered with an efflorescence of alkali, in which there is salt, as revealed in tasting it	30	0
5. Compact white siliceous sandstone, like that marked No. 3	6	10
6. Dull bluish-gray limestone, in layers of about a foot thickness, having shaly arenaceous and argillaceous beds between. Near the top are soft greenish and pink shales. All the beds are more or less gypsiferous	35	0

	Thickness. Ft.	In.
7. Yellow siliceous sandstone	2	0
8. Soft green sandstones and argillaceous shales		
9. Space covered where the section was made, but as seen from a distance lower down the river filled with beds similar to those of No. 8	40 to 50	0
Top.		
Total thickness about	242	7

Above layer No. 9 is a massive siliceous sandstone, which I have taken as the base of the Dakota group, for reasons that will be given when I describe the Dakota group at this locality. Below the section are pink sandstones, resting on the red sandstones, referred to the Triassic.

The colors of these layers gives a unique and striking appearance to the cañon-walls. Farther south and west this variegated appearance seems to be more marked.

In the Painted Desert in Arizona, Newberry* gives the following section of the beds:

Variegated marls.

	Thickness. Ft.	In.
1. Light orange marl	15	0
2. Green and purple magnesian limestone, containing worm-like concretions of calcareous spar	5	0
3. Pinkish-purple marl	22	0
4. Brown shelly sandstone	0	8
5. Purple marl with silicified wood	16	0
6. Purplish green cherty magnesian limestone, in several layers, alternating with bands of marl	8	0
7. Purple and cream colored marls	30	0
8. Greenish magnesian limestone in thin layers, with bands of marl	12	0
9. Yellow, red, and purple marls	40	0
10. Green limestone, similar to No. 8	3	0
11. Red, purple, pink, green, lilac, brown, and blue marls with silicified wood	350	0

Marcou† refers these beds to the Trias, regarding them the equivalent of the *Marnes Irisées* of France and of the *Keuper* of Germany. He says, "The third division or upper group of the Trias is subdivided again into two parts. The lower is formed of thick beds of whitish-gray sandstone, often rose-colored and even red; and the upper consists of beds of sandy calcareous clay, of very brilliant colors, violet, red, yellow, and white—in a word of variegated marls. This upper portion presents a striking resemblance, as to the rocks, with the *Marnes Irisées* of France, or the variegated marls of Europe."

Above the section (No. 9) I made on the Gunnison is a bed of massive sandstone succeeded by shaly and marly beds, in the upper portion of which is a lignitic layer.

Above the variegated marls of the section given above, Newberry‡ found a bed of lignite which he considered to be of Jurassic age. Whether this is identical with the lignite in sections Nos. 12, 13, and 14, I cannot positively determine, but I think it improbable, as the beds below do not seem to be identical. If they are identical, I place the lower limit of the Dakota group lower than he did. The reasons for so doing will be stated hereafter. Newberry, in his sections of what he considers the base of the Lower Cretaceous, also finds a lignitic bed, which is probably the one I have included.

Newberry§, in speaking of the lignite, says: "The sandstone shales and limestones lying above also include many beds of lignite closely

*Ives's Colorado Exploring Expedition, Geological Report, page 79.
†Geology of North America, page 13.
‡Ives's Colorado Exploring Expedition, Geological Report, page 81.
§Ives's Colorado Exploring Expedition, Geological Report, page 83.

resembling this, and on lithological grounds would be appropriately grouped with it. In fact they have been considered Jurassic, and the only Jurassic rocks in this region, by the geologist who claims to have discovered the representatives of this formation in New Mexico. Unfortunately, however, for that classification, immediately over the thin stratum of yellow sandstone which overlies the coal are beds of clay-shale with bands of limestone in which are unmistakable Cretaceous fossils. It is, therefore, evident that the Jurassic formation cannot be extended in this direction, and there is no alternative left but to consider the coal-seam, if Jurassic, the sole representative of the Jurassic series, or to combine with it some portion of the underlying variegated marls, which, for this purpose, must be abstracted from the Trias of Mr. Marcou."

CRETACEOUS.

It is, perhaps, impossible at present to subdivide the Cretaceous formation, as seen west of the continental divide, in the same manner as has been done east of the mountains.

For the sake of convenience in description, it may be best to consider it as divided into three groups, Lower, Middle, and Upper Cretaceous, as follows:

		Thickness in feet.
Lower Cretaceous—	Dakota group (No. 1)	500–700
Middle Cretaceous—	Fort Benton group (No. 2), Niobrara division (No. 3), Fort Pierre group (No. 4),	2,000
Upper Cretaceous—	Fox Hill beds (No. 5). A series of shaly sandstones, which in the lower part are lignitic. On Anthracite Creek this lignite is changed into anthracite coal	1,500–2,000
Total		4,000–4,700

This table represents the estimated thicknesses as developed in our district.

LOWER CRETACEOUS.

Dakota group—Formation No. 1.

Immediately above the group of shales last described, under the head of Jurassic and conformable to it, is a series of beds in which rather massive siliceous sandstones predominate. It is persistent throughout the Rocky Mountains, preserving its lithological characters very constantly over widely-separated areas.

The group forms a convenient horizon for reference, being more strongly marked, perhaps, than any other in the sedimentary series. Its age is well established, and I will therefore not take the space here to repeat the evidence. The discussion in full will be found in Professor Lesquereux's "Cretaceous Flora of the West." *

The evidence as to its identity in Colorado is as follows:

During the explorations of 1873, near the exit of the South Platte River from the mountains, I found fragments of a *Proteoides*,† of which Professor Lesquereux, writing me, said: "It is very near *Proteoides acuta* (Heer.), if not a small form of the same."

As yet no leaf of this genus has been found higher than the

* Report of United States Geological Survey, vol. vi; Cretaceous Flora, by Leo Lesquereux.

† See Report of United States Geological Survey for 1873, page 196.

Dakota group. In the same series I also found, near Glen Eyrie, a few miles from Colorado City, specimens of a lingula too indistinct for specific identification. In the Elk Mountains numerous impressions of dicotyledonous leaves were noticed, most of them fragmentary and indistinct.

On the Gunnison River during the past season (1874) I found a fragment of a sassafras-leaf like *S. mirabile*, near station 60, and in the bluffs near the mouth of the Gunnison I obtained a Cretaceous *Scaphite*. In various parts of the Elk Mountains Mr. Holmes found impressions of a *Salix*.

Professor Newberry* recognized the group in New Mexico. I shall hereafter refer to the identity of his sections with those made by me on the Gunnison.

Speaking of the rocks as exposed in New Mexico, he says: "The paleontological evidence of the age of these rocks is quite conclusive and of unusual value, as it fixes the place in the geological scale, of a well-marked formation in New Mexico, and one which has been the subject of considerable discussion. In the second member of the Cretaceous portion of the section, counting from the base upward, are contained fossils which are characteristic of the Cretaceous formation in Texas and Nebraska. These are *Inoceramus crispii* and *Gryphæa pitcheri*, well known Cretaceous fossils, common in Texas and the Indian Territory, and, in greater numbers, specimens of an ammonite (*A. pericarinatus*), highly characteristic of Nos. 1 and 2 of Meek and Hayden's section of the Cretaceous rocks on the Upper Missouri. There is no doubt of the parallelism of the group of sandstones with those of the base of Meek and Hayden's Cretaceous section."

The lithological characters will be shown in the various sections given, as I consider the formation according to its geographical distribution in our district.

Eagle River.—Until we reach the head of the second cañon there are no outcrops of Cretaceous age on the south side of Eagle River. Here, however, the sandstones of the Dakota group cross from the north and form a semicircular ridge, crossing to the north side again at the lower end of the cañon. In Plate II the group on the north side at the head of the cañon is shown at *a a*.

The semicircular line of outcrop is shown on map A. Stations 6 and 7 were located on its edge. The dip of the strata on station 6 was North 5° East, and on station 7 North 85° East, the angle of inclination about 20°. In this basin, included between the ridge and the river, the overlying strata have almost entirely been removed, the upper part of the group forming the greater part of the floor of the depression or semiquaquaversal. A section through the center of this basin is shown in Fig. 1, Plate I, from the point *a* to the Eagle River. I was unable to get a section here, so that I cannot say how thick it is. On station 6 the rock is a coarse white siliceous sandstone. Where it is in contact with the volcanic rock, as seen in the section and on the map, it is metamorphosed.

Below station No. 7 there is the following section, from below up:

1. Gray sandstone, greenish coating on the surfaces of the laminæ.
2. Hard greenish mottled limestone.
3. Greenish gray sandstone.
4. Blue limestone.
5. Sandstones forming the station.

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* Ives's Colorado Exploring Expedition, Geological Report, page 85.

The lower portion of this section is probably Jurassic.

The area of Cretaceous represented on the map lying between the semicircular ridge and *g* creek is probably almost entirely of the sandstones of the Dakota group. There may be some of the layers of No. 2 and No. 3 in places, as shown in Fig. 1, Plate I. There are no other outcrops of No. 1 on Eagle River or its tributaries within the limits of our district.

Grand River.—Between the Grand and Roaring Fork, at the head of Mesa Creek, there are, judging from the view we had from station No. 11, outcrops of the Dakota group dipping to the southwest. It also outcrops beneath the mesa between this creek and Frying-Pan Creek, near the base, on the south side. Between the Grand and Roaring Fork there may be a few patches of Cretaceous, but, if so, I think they are of higher beds than the Dakota group. On the west side of Roaring Fork it forms the summit of the prominent hog-back ridge. On station 14 it is a massive light grayish siliceous sandstone, the outcrop of which measures 63 feet. If the beds marked 8, 9, and 10, in the section of the Jurassic (section No. 8) made here, are included, the following would be the section of the Dakota group at this point.

No. 10.—*Section on Station No.* 14.

Top.	Thickness in feet.
1. Massive grayish white siliceous sandstone	63
2. Brown sandstone, with fine black shales	20
3. Dark brownish-gray sandstone, becoming light-colored near the top	15
4. Light greenish sandstone	125
Base.	
Total, about	203

The character of these beds, I think, warrants their being considered Cretaceous rather than Jurassic. The black shales in No. 2 probably occupy the same horizon that in the other places is filled with the lignitic beds. If they are not considered Cretaceous we have only a thickness of 63 feet for the Dakota group. Above the layer marked No. 1 the beds have been eroded and covered with the *débris*, leaving a valley between the hog-back and the hills to the west. On the Grand, below the mouth of Roaring Fork, the Dakota group comes out from beneath the volcanic rock of station 16. At station 14 the strike of the hog-backs is north 15° west, and the angle of dip 30°. Station 17 was on the sandstones of the Dakota group. The inclination here is 35°. This seems to increase to 50° or 60° to the westward. The strike is north 75° to 80° west. The hog-backs extend about seven miles beyond station 17, when they cross the river into Mr. Marvine's district, and the Grand, from that point to the mouth of the Gunnison, flows through beds of higher horizons, not reaching the No. 1 until the river is joined by the Gunnison. Here it outcrops in the bluffs. I will reserve the description to the section devoted to the Gunnison.

Gunnison River.—At several points bordering the meadow-like expansions of the valley of the Gunnison below the mouth of Cochetopa Creek, there are indistinct outcrops of sandstones that probably represent a portion of the Dakota group. As we proceed down the river these outcrops become more distinct, and below station 73, besides the No. 1, shales of No. 2 are represented, shown at *c* in Fig. 1, Plate XIV. The Cretaceous rocks seem to have been subjected to considerable erosion, preceding the lava flow that has covered them. This is shown by the change in the strata shown in the figures in Plate XIV, which are sections on the north

side of the Gunnison at various points between the mouth of Cochetopa Creek and the mouth of Lake Fork.

The drainage had probably then the same general direction it has at present. In Fig. 2, Plate VII, beneath station 77, at the point *d*, we have on top of the Dakota group a few shales. Farther north, at station 79, there is greater thickness, reaching in all probability as high as No. 4. The wearing down was probably from north toward the south, which is the general direction of the streams at present.

The following section was made from the point *a* to *b*, in Fig. 1, Plate XIV.

No. 11.—*Section of No.* 1 *Cretaceous, beneath station* 73 *north side of Gunnison River.*

Base.	Thickness in feet.
1. Dark micaceous gneiss	
a–2. Siliceous sandstone, general color yellowish, becoming pink and white in places. The lower portion is somewhat concealed in beds that are massive	43
3. Siliceous sandstones like those of No. 2, general color pink. These sandstones are not so massive as those of No. 2. They are somewhat laminated	58
4. Yellow sandstones in bands of two and three feet thickness	32
5. Sandstones and interlaminated shales. The general color of the sandstones is yellowish; some of the layers have greenish pebbles. The shales near the top are greenish	79
6. Laminated brownish-gray sandstones in bands from a foot to eighteen inches in thickness. There are greenish-gray interlaminated shales. Some of the sandstones are probably argillaceous and weather into rounded bowlder-like masses	6
7. Space filled with bands of sandstone and soft argillaceous shales and limestones. In the lower part there is a nodular limestone with pebbles of red jasper. The upper parts of the sandstones are faintly tinged with purple	82
8. Greenish and yellowish indurated argillaceous sandstones and shales, resembling the beds of No. 7	52
9. Soft yellow and white laminated sandstones	16
10. Soft pinkish laminated sandstones	14
11. White argillaceous sandstones and shales; some of the beds are indurated and break with a conchoidal fracture. The sandstones weather with rounded corners, forming bowlder-like masses as in the case of No. 6	54
12. Massive yellow siliceous sandstones, about	100
Top.	
Total, about	536

These sandstones and shales are exposed on both sides of the river beneath the breccia, and also for some distance up the lateral branches.

North of the Grand Cañon the gently-sloping surface between the Gunnison and Smith's Fork is underlaid by the Dakota group, which forms a bluff-like edge above the granitic shelf bordering the cañon. The slope is about four degrees in a direction a little east of north. Smith's Fork cuts through the No. 1 almost parallel to its strike. The beds here have the same general character that was noticed in the section given above. In some places on Smith's Fork I noticed black coaly-looking shales, and in some of the laminated sandstones were ripple and mud marks.

Near the head of the south branch of Smith's Fork the gentle slope of the Dakota group is broken and the stream flows through a small cañon caused by the breaking. This cañon is marked *a a* on map B. It is only about two miles long. On the west side the dip of the strata is 5°, while on the east it is 15° or 20°. In the latter place it forms a small, almost triangular area, of which the base is toward the west. The fracture determining this cañon was probably the result of a fold, which may have been caused by igneous action, contemporaneous with the elevation of the trachytic hill opposite the mouth of the

creek. Between the cañon and station No. 38 there are two areas of trachytic rock, which may also have had something to do with it. On the south side of the Grand Cañon the Dakota group does not appear at the upper end, shales of higher positions abutting against the schists, as shown in Fig. 2, Plate VII.

In the angle included in the great bend of the Gunnison, opposite the mouth of Smith's Fork, the sandstones of No. 1 form the surface. Sections across this area are shown on Plate VIII, the letters giving the lines on which they are made, as represented on map B. On the west side of this area the beds dip steeply, and in the valley of the Uncompahgre the Dakota group is covered with the overlying beds of later origin.

A short distance above the mouth of Roubideau's Creek it appears again, forming bluffs that gradually rise as we go down until the river is again in cañon (Unaweep Cañon.)

The following is a section of the bluff on the Gunnison opposite the mouth of Roubideau's Creek:

No. 12.—*Section of Cretaceous No. 1.—Bluff on Gunnison River.*

Top.	Thickness Ft.	In.
1. Space reaching from the top of the bluff, which is covered with bowlders of sandstone and volcanic rock, underlaid, in all probability, with sandstones and shales	50 to 60	0
2. Massive yellow sandstones	10	0
3. Space in which the upper part is occupied with gray and rust-colored sandstone shales, with carbonaceous material. The lower portion of the space is probably filled with layers similar to those above. The slope is covered with the *debris* of sandstones in which there are fragmental impressions of stems, but no leaves, although careful search was made	31	0
4. Gray laminated sandstones	33	0
5. Black carbonaceous or lignitic shales with efflorescence of alkali	1	6
6. Yellow and gray shaly sandstones	4	0
7. Fine black carbonaceous shales	6	0
8. Massive gray sandstone	10	0
9. Shaly sandstones alternating with shales like those of No. 5	22	0
10. Coarse, white, granular siliceous sandstone	2 to 4	0
11. Sandstone shales reaching to the base of the bluff	16 to 18	0
Base.		
Total, about	199	6

This represents only a portion of the No. 1. The river, however, soon cuts through to its base. The area occupied along the eastern side of the Gunnison by the Dakota group is limited to a narrow belt, the higher beds outcropping in low bluffs from three to five miles from the river.

A section at station 60 is given below:

No. 13.—*Section of No. 1 Cretaceous.—Bluff on east side of Gunnison River, Station 60.*

Top.	Thickness. Ft.	In.
1. Massive yellow siliceous sandstones, with indistinct impressions of leaves and stems. The sandstones are so coarse that nothing recognizable could be seen	54	0
2. Blue argillaceous shales, gypsiferous		6
3. Fine black lignitic shales with interlaminated sandstones and clays	18	6
4. Blackish-gray laminated sandstones and shales	31	8
5. Soft gray sandstones with greenish shales in the upper part	25	4
6. Soft argillaceous sandstone shales in bands of red and green colors alternating	25	4
7. Yellow siliceous sandstones in rather massive layers, very much like those in No. 1, given above	63	0
8. Blue and yellow mottled argillaceous sandstone shales	6	4
9. Fine red and green shales, argillaceous and probably calcareous	5	10

Base.	Thickness. Ft.	In.
10. Compact, fine-grained, brownish-red sandstones, with interlaminated shaly beds with a cross-fracture	47	6
11. White, dendritic, argillaceous sandstones, indurated near the top, and having a sharp, conchoidal fracture	8	0
12. Greenish and purplish argillaceous shales	19	0
13. Yellow siliceous sandstone, rather massive in the lower part, laminated above	6	4
14. Reddish and whitish-green mottled sandstones, grading up into soft shales	8	0
15. Reddish, purplish, and greenish sandy shales, mottled	24	0
16. Greenish-white, argillaceous sandstone, weathering into rounded masses like bowlders		
17. Brick-red shales mottled with green		
18. Pink sandstone, 1 foot	68	6
19. Greenish shaly sandstones, with hard bands of sandstone at intervals, and fine red shales in laminæ, 6 inches in thickness		
20. Soft greenish conglomeritic sandstone. The upper bed is a green sandstone, below which is an irregular mottled limestone, argillaceous, brown, reddish, and greenish, with jasper in center of nodules. In the center there are also quartz and calcite. Some of the beds in this space are concealed	43	0
21. Massive yellow siliceous sandstone, coarse in places, with siliceous pebbles	10	0
22. Soft white sandstones, conglomeritic at the base, containing black, red, and yellow pebbles; very fine	1	6
23. Soft shaly beds, partially concealed by argillaceous *débris*. These beds are composed of greenish-gray, argillaceous sandstones, brownish nodular limestone, and greenish clays. Nearly all the beds are gypsiferous. The sandstones break into rounded pieces. The *débris* is coated with a salty, alkaline efflorescence	30	0
24. Space in which the slope is partially covered with *débris* of hard red sandstone and dark gray sandstone, and indurated argillaceous beds of a purplish sandstone; near the top was an outcrop of dark brownish-gray sandstone. In the *débris* below I found a specimen *Sassafras*, like *S. mirabile*, in a rock similar, but was unable to find any fossils in place	55	0
25. Yellowish siliceous sandstones, generally in massive beds, but toward the base somewhat laminated	100	0
Base.		
Total about	651	0

I think it likely that most of the argillaceous beds given above in the section are calcareous. I had no means of testing them on the spot. The nodular bed of limestone in No. 20 is identical with that in No. 7 of the section No. 11 at station 73. The jaspery pebbles are the same. They are bright-red and have calcite in cavities in the center of irregular masses. The calcite is deep yellow.

There is a partial outcrop of the Dakota group in the bluff between the Gunnison and the Grand at the mouth of the latter. The following is the detailed section at this point:

No. 14.—*Section of No.* 1 *Cretaceous.—Bluff on Gunnison near the mouth.*

	Thickness. Feet.
1. White siliceous sandstone at base of bluff. Thickness could not be ascertained, only upper part showing	
2. Fine black lignitic shales	5
3. Gray siliceous sandstone with shaly beds.	
4. Beds of soft friable lignite with bands of dark greenish-gray sandstone filled with fragments of stems and carbonaceous material. These sandstones are in bands of one foot to two feet thickness. The lignite is of poor quality, decomposing rapidly on exposure to the atmosphere	150 to 160
5. Yellow siliceous sandstones with massive structure below and becoming shaly above. The lower portion is gypsiferous.	
Total	155 to 165

The lignitic beds No. 2 in this section correspond with No. 2 in the sections made near Roubideau's Creek and station No. 60 (sections Nos. 12 and 13). In the section made near station 73 (No. 11) this layer seems to be absent, as it also is in the section made at station 14 on Roaring Fork.

It is probably this bed that Dr. Schiel refers to in the Geological Report of Captain Gunnison's exploration when he says: "In the Valley of the Blue River, a coal-measure, supported by sandstone, crops out at several places, but the coal does not seem to be of good quality."

Professor Newberry gives the following detailed section made in Arizona:

	Feet.
1. Coarse yellowish sandstone, with concretions of oxide of iron, and obscure impressions of dicotyledonous leaves	16
2. Impure coal, alternating with bands of bituminous shale and fire-clay, containing fossil-plants—*Clathropteris*, *Cyclopteris*, *Sphenopteris*, *Pécopteris*, &c.—all new species	12
3. Fire-clay and shale	3
4. Coarse, compact, white concretionary sandstone	6
5. Green marl	25
6. Bright red marl	22
7. White, soft, saccharoidal calcareous sandstone to base	

Layers 3 to 7, inclusive, are probable Jurassic.

At another point, not far distant from where the section above was made, Professor Newberry made another section, of which the following is a portion:

	Feet.
11. Coarse light-yellow or whitish massive sandstone	120
12. Green shales, with bands of ferruginous sandy limestone and beds of lignite. In this group at Oraylee and Camp 96 are *Pinna ? lingula* (n. sp.) and *Gryphæa pitcheri*; and over the lignite beds are impressions of leaves of *Platanus*, *Alnus quercus*, &c., and fossil ferns of the genus *Sphenopteris*	90
13. Green, blue, and gray argillaceous shales, with bands of brown or yellow siliceous limestone, containing *Ammonites pericarinatus*, *Inoceramus crispii*, and *Gryphæa pitcheri*, var. *navia*	160
14. Coarse yellowish sandstone, precisely like Nos. 9 and 11 (base of Cretaceous formation ?)	25
15. Lignitic, (Jurassic ?) better than that above, to base.	

The bed of lignite, which he marks Jurassic? is the layer marked No. 2 in the first section given above, while No. 14 corresponds with No. 1.

Comparing these sections with those I made on the Gunnison River, the lithological similarity is evident.

I think it probable that his beds of lignite, marked No. 12 in the section given above, are identical with the layers included under No. 3 in my sections on the Gunnison (Nos. 12 and 13). If so, the bed of lignite which he considers as Jurassic is wanting in my sections, while his layers, marked Nos. 13 and 14, correspond to those included in Nos. 23, 24, and 25 in section No. 13, made at station 60. It is a curious coincidence that the thickness given by him (185 feet) is the same as that given by me. This, however, is no positive proof of identity, as these beds vary in thickness in localities very close to each other.

If the beds do not belong to the same horizon, I have placed the line of division between the Cretaceous and Jurassic layers lower than Professor Newberry has done. The specimen of *Sassafras* that I found in bed 24 of section No. 13, is the only evidence I have upon which to ground such a separation.

Speaking of the specimen *Pecopteris* that he found in the lignite bed (No. 2 of his first section given above), Newberry says, "Associated with *Clathropteris* of Jurassic affinities, and with the first appearing species of the dycotyledonous plants of the Cretaceous epoch, this

Pecopteris confirms the inference derived from other sources, that the lignite bed containing it lies just at the point of junction between the Cretaceous and older rocks, and showing a mingling of forms belonging to the two formations, proving the impossibility of drawing sharply the lines of division."

In the bluffs, at the mouth of the Gunnison, below the lignitic beds, I found a specimen of *Scaphite*, which marks the layer of Cretaceous age. It probably represents the equivalent of layer No. 13 in the second section given above by Newberry. If so, the identity of the sections with mine would seem to be pretty clearly indicated.

MIDDLE CRETACEOUS.

As I have already indicated, it is impossible in our district to give the exact limits of the different formations comprehended under No. 2 to No. 4, inclusive. As the shaly character prevails throughout the series, I have included them all under the same head. At the base in No. 2 they are decidedly arenaceous, the beds just above the Dakota group being laminated sandstones. Gradually they become more and more argillaceous, and near the top thin bands of limestone appear.

Cretaceous No. 2 and No. 3.

Exposures of the Fort Benton group and the Niobrara division are seen in the valleys of the Grand and Gunnison Rivers, and on the North Fork of the Gunnison. Want of time precluded the possibility of making a complete section from the base of the series to the top, although I succeeded in getting several sections which will give the general characters of the strata. The layers of No. 2 were not generally so well exposed as those of No 3. The higher we go in No. 2, as exposed in our district, the more shaly and argillaceous do the beds become, and in No. 3 they are also calcareous.

Eagle River.—On the north side of Eagle River, opposite the second cañon, as viewed from the semicircular ridge of stations 6 and 7, the Fort Benton group and succeeding divisions of the Cretaceous are seen outcropping in the most beautiful manner, as shown in Plate II (between *b* and *c*). On the south side all have been removed except a few remnants of No. 2, and perhaps also of No. 3 in places, leaving the sandstones of the Dakota group as the floor of the semiquaquaversal already described. Still farther south, in the circular area of Cretaceous near the Eagle (see map A), remnants of No. 2 and No. 3 are seen, as shown in the section in Fig. 1, Plate I.

Grand River.—In the range of hog-backs, extending from the Elk Mountains along Roaring Fork and Grand River, and finally crossing the latter, there are exposures of all the Cretaceous strata above the Dakota group. There was no opportunity here to make any sections.

On the south side of Grand River, in low bluffs above the mouth of the Gunnison beds of No. 2 and No. 3, outcrop, black shales prevailing.

Gunnison River.—Under the rhyolitic and breccia-covered areas, bordering the Gunnison above the Grand Cañon, there are in all probability fragments of formations No. 2 and No. 3. They are exposed beneath the mesas that stand between Slate or East River and Ohio Creek. The exposures of the beds immediately above No. 1, between the North Fork of the Gunnison and Rock Creek, will be referred to by Mr. Holmes, in his report on the geology of the Elk Mountains.

Between Smith's Fork and the North Fork of the Gunnison there is

wide area, in which the strata almost entirely belong to No. 2 and No. 3. There are two parallel lines of bluffs, the first composed of black shales, which are also shown along the course of the North Fork. Some of the upper beds may belong to No. 4.

The following is a partial section on a line between station 38 and station 80.

Section No. 15.

Base.	Thickness. Ft. In.
1. Trachyte, about 75 feet thick	
2. Gray and black argillaceous, with *Inoceramus*	58 0
3. Shales and bluish slates	100 0
4. Slope covered with *débris* of shales above	32 6
5. Bluish slates weathering rust-color, in laminae ⅛ of an inch thickness, containing *Inoceramus* and fish-scales, too indistinct for identification	160 0
6. Gray and grayish-blue limestone with interlaminated shales, containing *Inoceramus* and fish-scales	160 0
7. Dark bluish and black shales	243 0
Total, about	753 6

At the base of the mesa, which ends east of the Gunnison below its mouth, No. 2 and No. 3 outcrop. The following section was made north of the Gunnison, opposite the mouth of Roubideau's Creek. It will give the characters of the beds. They may all belong to the Fort Benton group, or the upper portion of the section may possibly represent a part of the Niobrara division.

Section No. 16.—Gunnison River, opposite Roubideau's Creek.

Base.	Thickness. Ft. In.
1. Shaly sandstones, with interlaminated argillaceous beds extending from the top of the bluff on the river to the base of the first bluff north of the river. The beds are for the most part concealed 2. Coarse yellow sandstone, with calcite 3. Gray laminated sandstone	175 0
4. Thin laminæ of grayish sandstone shales, with fine black argillaceous shales, gypsiferous and calcareous, containing *Inoceramus, Ostrea lugubris* (Conrad), and other Cretaceous fossils	125 6
5. Yellowish sandstone shales, with quantities of *Inoceramus* and *Ostrea* especially abundant near the top, where there is a layer of black shales	40 0
6. Black argillaceous shales, partly concealed by *débris*	38 0
7. Coarse yellow, gypsiferous, and calcareous sandstones, with layer at top, breaking into pencil-like pieces one to two inches long and an eighth of an inch in thickness	50 3
8. Sandstone shales 9. Fine black argillaceous shales	120 0
10. Coarse yellow calcareous sandstone, resembling that described under No. 7.	1 0
11. Fine black argillaceous shales, with bands of sandstone (fossiliferous), species of *Inoceramus* and *Ostrea*	36 0
12. Hard gray sandstone	1 0
13. Very fine, soft, black argillaceous shales, with a few laminæ of gray sandstone. In the lower part of the group the shales are coal-black, but as we ascend they become gray-black. Nearly all the layers are fossiliferous. Among the forms are *Prionocyclus wyomingensis*, *Scaphites warrenana*, and *Inoceramus problematicus*. They are especially abundant near the top	66 6
14. Fine gray and yellowish shales	34 0
15. About 17 feet of gravel, composed largely of basaltic bowlders, forming the top of the bluff	......
Total, about	687 3

Near station 73, on the Gunnison, shales belonging to formation No. 2, outcrop beneath the breccia that underlies the rhyolitic covered mesa. (*c*, Fig. 1, Plate XIV.)

They are 25 to 30 feet in thickness, and represent but a portion of the group.

Under station 79, on the south branch of Smith's Fork of the Gunnison, there is a greater thickness exposed, some of No. 3 probably showing, although I cannot be certain, as I had no opportunity of making a section. These strata are the direct prolongation of those exposed in the open country between the North Fork and the north branch of Smith's Fork of the Gunnison.

CRETACEOUS NO. 4.

Unfortunately opportunity did not offer to study in detail the strata referred to the Fort Pierre group and the Fox Hills beds. I was unable to tell where No. 3 ended or No. 4 began; the thickness, therefore, could not be given. I estimated the thickness of the series from No. 2 to No. 4, inclusive, at from 1,500 to 2,000 feet. The only fossils obtained were specimens of *Avicula linguaformis* and *Inoceramus barabina*, from an outcrop of bluish indurated clay in the valley of the Gunnison, near Kahnah Creek, beneath station 58. This layer, I think, belongs to formation No. 4. No. 4 and No. 5 outcrop in all the localities where Nos. 2 and 3 are seen, with the exception of station 73, where No. 2 alone is seen beneath the breccia, the other beds having been eroded previous to the deposition of the breccia. The best exposures are seen in the valley of the Gunnison, but even here the softness of the beds renders them readily eroded, so that they are concealed by the *débris* of the strata, and it is difficult to make a connected detail-section. The strata of No. 4 are largely light-gray and bluish argillaceous beds, with sandstones near the top that give a yellowish *débris*. They pass gradually into the sandstones and shales of No. 5. In No. 5 the arenaceous character prevails. The group next to be described may belong in part to No. 5, or may, perhaps, be an extension of it. Until fossils are found in it, its position is somewhat indefinite, and I have therefore considered it separately.

UPPER CRETACEOUS.

I had no opportunity of estimating the entire thickness of the beds included under this group. In the Elk Mountains, where they are seen most extensively, there has been so much disturbance of the strata that it is difficult to obtain connected sections.

On Coal Creek there is a bluff in the face of which are exposed 1,500 feet of light-gray and yellowish sandstones and shales. On the North Fork of the Gunnison, the exposures must be of greater thickness. The upper part of the series, however, is not shown here. The coal occurs in the lower part of the series, as shown on Coal Creek. The sections will best illustrate the character of the beds. In the broad valley east of station 48, and south of Grand River, are chocolate-colored shales, and greenish and gray sandstones that should probably be referred to the upper part of the series. The following is a partial section made on a small branch of the Grand, below station 19.

No 17.—Section south of Grand River.

Base.	Thickness. Feet.
1. Coarse soft whitish sandstone	3
2. Greenish sandstone, coarse and soft	4
3. Hard brownish limestone 4. Space covered with a reddish-brown *débris*, probably underlaid by alternating sandstones and limestones	15

Base.	Thickness. Feet.
5. Light gray sandstone	1
6. Space covered with a brownish *débris* in which are nodular masses of brown limestone; near the center of the space is a band of white sandy *débris*	45
7. Black argillaceous shale; 8. White sandstone	5
9. Space covered with *débris*, in which are occasional outcrops of black and reddish shales	26
10. Rather massive light greenish-gray sandstone	8
11. Greenish and purplish shales	6
12. Bluff of yellowish sandstone, massive below, becoming shaly above, containing fragments of stems and leaves	104
Total, about	217

In layer No. 12 I found an indistinct *Aralia*, which Professor Lesquereux considers Cretaceous. The section on station 26, still farther south, was given in chapter III.

On the ridge dividing "Oh be Joyful" Creek from Anthracite Creek, near station 32, I made the following section, the letters corresponding with those in the illustration in Plate X:

Section No. 18.—Head of "O be joyful" Creek.

	Base.	Thickness. Feet.	In.
E.	1. Massive white sandstone, reaching from the base of the cliff for several hundred feet; 2. Gray shales, succeeded by massive sandstone; 3. Black shales and rusty sandstone; 4. White sandstone succeeded by hard bluish sandstone	500	0
D.	5. Bluish-gray laminated sandstones	7	9
	6. Conglomeritic sandstone, gray below, becoming yellowish toward the top. There are pebbles of red jasper	15	9
	7. Purplish and yellowish argillaceous shales	11	6
	8. Metamorphosed conglomerate	3	0
	9. Metamorphosed sandstone, white and greenish below, purplish above; some of the layers are conglomeritic	77	9
	10. Fine-grained, very compact, purplish sandstone, breaking into small cubical blocks	4	5
	11. Greenish and purplish argillaceous shales, in thin laminæ	11	10
	12. Purple sandstone resembling that of No. 10, more laminated at the top	12	0
	13. Purple and yellow argillaceous shales	10	0
C.	14. Greenish trachyte in massive layer	18	0
B.	15. Greenish and gray shales, partly argillaceous	11	8
	16. Dull greenish coarse sandstones	17	0
	17. Greenish and purplish mottled sandstones, generally compact, breaking into irregular pieces; some layers are conglomeratic	35	0
	18. Compact purple sandstones, in bands of eight inches to a foot thickness, breaking at right angles to the plane of deposition. On the surfaces quartz crystals are numerous. This bed forms the top of the bluff	88	0
	Total, about	833	8

Most all these sandstones have a metamorphosed appearance, and the ridge in which they are exposed is intersected with dikes, which will be described in a subsequent portion of the report. Below the strata of the section just given there are probably 1,000 feet of shales and sandstones to a series of coal-bearing strata on "Oh be Joyful" Creek. The latter, according to Mr. Holmes's estimates, is about 2,000 feet above the Dakota group. The upper portion of these beds may possibly have to be referred to the Lignitic group, but for the present I refer them to the Upper Cretaceous.

On one of the small southern branches of Anthracite Creek, near its head, is an outcrop of anthracite coal. We found the float in the creek-

Plate X.

Bluff at head of "Uh be joyful" Creek.

bed, and followed it up until the bed was reached, near the head of the stream. The original discovery was made, I believe, by prospectors. The existence of coal of a good quality in the Elk Mountains has been known for several years. In the report for 1873 (page 259) I referred to it.

The coal was exposed on both sides of the creek, the dip being nearly in the direction of the course of the stream, inclining about 25°. The beds are tipped up against the Trachytic range that forms part of the divide between Anthracite Creek and Ohio Creek. The coal is in a bed from 4 to 5 feet thick. The following is the section from the coal down:

1. Coal, 4 to 5 feet thick.
2. Black slates and shales, with interlaminated dark sandstones, reaching to the creek-bed, about 150 to 200 feet thickness in all.

Above the coal is a bed of sandstone, brownish near the coal, becoming lighter colored as we ascend. The sandstone is succeeded by light-gray sandstones and interlaminated dark shales. About 100 feet above the coal is a layer of porphyritic trachyte, which inclines with the sedimentary beds. It is probably an intrusion, as it resembles closely the trachyte from the various eruptive masses in the surrounding country. It contains iron, which gives it a rusty appearance on weathered surfaces. The coal will be referred to in a subsequent part of the report, when analyses will be given. Coal is also found on Coal Creek, and at the head of Slate River, and on Rock Creek. It is all probably of the same age.

In sandstone shales, near Mount Marcellina, I found a specimen of *Ferrea sternbergii*. Although I searched carefully, this was the only fossil I could find that was distinct enough for identification. This and the *Aralia* I found in layer 12 of section No. 17, on Grand River, are the only fossils found in the series and do not warrant any definite conclusion as to their age.

The beds in section No. 17 have probably their equivalents in section No. 18, but in the latter they have been so changed that we cannot say so with any certainty.

I have already referred to the possibility of a portion of this group being a part of the Fox Hills beds (No. 5). A part, also, may belong to the Lignitic group, (so named east of the mountains.)

Since writing the above I learn from Mr. Marvine that he found a coal-bearing series of shales above typical specimens of No. 4 Cretaceous, and that above the coal he obtained fossils referred to No. 5 by Prof. F. B. Meek.

Dr. Endlich also found coal above No. 4 in the Cretaceous.

It is therefore probable that the beds I have, for convenience, described as Upper Cretaceous belong to No. 5.

From the lowest to the highest beds exposed in my district I could find no unconformability.

CHAPTER VII.

STRATIGRAPHY—CENOZOIC FORMATIONS.

In the present chapter I shall take up the remaining members of the sedimentary series as exposed in our district. These consist mainly of beds referable to the Green River and Bridger groups of the Tertiary, and I shall consider them without entering into any extended discussion as to the exact names that should be given them, whether Eocene or Miocene. Professors Cope, Leidy, and Marsh consider them Eocene, basing this conclusion on the discovery of vertebrate organic remains; while Lesquereux refers there to the Miocene from his investigations of their fossil flora, calling the "Lignitic" group Eocene. I shall simply describe the beds, giving the local names of the groups to which they are referred.

In regard to the "Lignitic" group, I am unable to present any details. Farher discussion as to the exact age of the group will be found in the other reports.

As to the Post-Tertiary formations, I am able to speak only in the most general way, and am unable to separate them into groups.

TERTIARY.

Above the beds characterized as Cretaceous by their lithological peculiarities and the occurrence of typical fossils, is a series of beds from 7,000 to 8,000 feet in thickness, covering a large area extending from the Grand River to the Gunnison beneath the basaltic plateaus west of Roaring Fork. This area is marked on map E.

The best exposures are seen on Plateau Creek. I had time only to make a partial detailed section. The strata are conformable to the underlying Cretaceous, and it is difficult to determine where one formation ends and the next begins. I have arbitrarily chosen as the base of the Bridger series a bed of red sandstone that is tolerably persistent beneath the variegated beds above which the fossils were found. Another year I hope to define the limits of the formation. The lower portion of the series is referred to the Tertiary with some hesitation, as the fossils, which were few in number, were found too far above to predicate anything very definitely. Before entering into any description of the groups as they occur in our district, I will give in tabular form the various views held by different authorities in regard to the beds that have been referred to the Tertiary formations with the exception of those referred to the Pliocene.

Fort Union or Great Lignite group.

Local ty.	Description of strata	Age.	Authority.	Reference.
At Fort Union, Fort Clark, and under the White River beds, on the North Fork of the Platte River, above Fort Laramie, and west of Wind River Mountains.	Beds of clay and sand, with round ferruginous concretions and numerous beds and seams and local deposits of lignite.	Eocene Tertiary ..	Haydon.......	Exploration of Yellowstone and Missouri Rivers, under Capt. W. F. Raynolds, 1859-'60; Geol. Report of F. V. Hayden, p. 29.
Upper Missouri region.	....	Tertiary	Meek and Hayden.	Proceedings Acad. Nat. Sci., Philadelphia, 1856, p. 63.
		Miocene Tertiary	...do	Do., p. 225.
		Lower Tertiary...	...do	Do., p. 113.
		Lower Tertiary...	Hayden.......	Transactions Amer. Philosophical Soc., 1860.
			Leidy	Do.
		Miocene	LeConte	Exploration of Smoky Hill Railroad route, 1868, p. 65.
		Tertiary	Hayden.......	American Journal of Sciences and Arts, 1868, p. 204.
		Cretaceous......	Cope..........	Transactions American Philosophical Soc., 1869.
		Miocene	Newberry	Annals Lyceum Nat. History of city of New York, vol. ix, 1868.
		Tertiary	Hayden.......	Report U. S. Geol. Survey of Ter., 1867-'68-'69, p. 57.
		Miocene	Newberry	Report U. S. Geol. Survey of Ter., 1870, pp. 95, 96.
		Cretaceous No. 6..	Cope.........	Report United States Geol. Survey, 1873, p. 433.
		Lower Eocene	Lesquereux...	Report U. S. Geol. Survey, 1872, pp. 410-417.
Extension into British America.	....	Eocene	G. M. Dawson	Canadian Naturalist, vol. vii, April, 1874, p. 252.
		Cretaceous.......	J. J. Stevenson	"The Geological Relations of the Lignitic Groups," read before the American Philosop. Soc., June 18, 1875.
Porcupine Creek, Missouri Coteau, West Souris River, and other parts of British America.	....	Eocene	G. M. Dawson	Report of British American Boundary Survey of Forty-ninth Parallel, pp. 6, 8, 18, 19, 86, 93, 97, 103, 152.
		Lower Eocene	....do	Do., p. 186.
Milk River	....	Lignitic Tertiary	Hayden......	Report U. S. Geol. Survey of Ter., 1867-'68-'69, p. 72.
Tongue River........	....	...do	....do	Do., p. 73.
Eastern base of Black Hills.	....	...do	....do	Do., p. 73.
Grand River, Nebraska, (now Dakota.)	....	Cretaceous.......	Cope.........	Report U. S. Geol. Survey of Ter., 1873, p. 446.
Lignite of Long Lake, Nebraska, (now Dakota.)	....	...do	....do	Do., pp. 453-'4.
Lignite of Big Horn Mountains, and at mouth of Big Horn River.	....	...do	....do	Do., pp. 453-'4.
Beds beneath White River beds, south of Fort Fetterman.	....	Lignite (Tertiary)	Hayden.......	Report U. S. Geol. Survey of Ter., 1870, p. 16.
North Platte River and La Prêle Creek.	....	Eocene...........	....do	Do., p. 22.

Fort Union or Great Lignite group—Continued.

Locality.	Description of strata.	Age.	Authority.	Reference.
Coal-beds under White River beds, near Fort Laramie and east of Rock Creek.	....	Lignite (Tertiary)	Hayden	Report U. S. Geol Survey of Ter., 1867-'68-'69, p. 79.
Laramie plains, one hundred miles west of Fort Laramie.	....	Lignite (Tertiary)	....do	Report U. S. Geol. Survey of Ter., 1870, p. 121.
Coal-beds of Carbon and Separation, Wyoming Territory.	....	....do	....do	Report U. S. Geol. Survey, 1867, '68, '69, p. 190.
At Separation and surrounding country. Probably same at Carbon, Rock Creek, Cooper Creek, and Creston.	Yellow, rusty yellow, rusty brown, and drab beds.	....do .... Lower Eocene.	....do	Report U. S. Geol. Survey, 1870, p. 139.
Carbon Station	....	Lower Miocene ...	Lesquereux...	Report U. S. Geol. Survey, 1871, p. 306
		Upper Eocene	....do	Report U. S. Geol Survey, 1871, pp. 410-417.
		Middle Miocene...	....do	Report U. S. Geol. Survey, 1873, p. 366.
		Middle Miocene...	....do	American Journal of Sciences and Arts, vol. vii, June, 1874.
Lignite beds east of Washakie Station.	....	Lower Tertiary...	Hayden......	Report U. S. Geol. Survey, 1870, p. 74.
		Eocene	Lesquereux...	Report U. S. Geol. Survey, 1871, p. 306.
West of Washakie, and in Bridger Pass.	....	Lignite Tertiary..	Hayden......	Report U. S. Geol. Survey, 1870, p. 74.
Coal-beds east of Salt Wells.	....	Eocene	....do	Report U. S. Geol. Survey, 1870, p. 71.
Coal-beds of Rock Springs, and east of Rock Springs and Salt Wells.	....	Lignite Tertiary..	....do	....Do.
Henry's Fork of Green River.	An immense thickness of sandstones and clays, extending from Green River beds to Cretaceous clays.	Eocene	...do	Report U. S. Geol. Survey, 1870, p. 58.
On St. Vrain's Creek, east of mountains in Colorado.	....	Lignite Tertiary	....do	Report U. S. Geol. Survey, 1867-'68-'69, p. 127.
Marshall Mine, Colorado.	....	Tertiary	....do	....Do., p. 129.
		Eocene	LeConte	Exploration of Smoky Hill Railroad route, 1868, p. —.
		Eocene	Lesquereux ..	Report U. S. Geol. Survey, 1871, p. 306.
Ralston Creek, near Golden City, and Golden City.	....	Tertiary	Hayden......	Report U. S. Geol. Survey, 1867-'68-'69, p. 134.
Golden City..........	....	Eocene	Lesquereux...	Report U. S. Geol. Survey, 1871, p. 306.
		Lower Eocene	... do	Report U. S. Geol. Survey, 1872, pp. 410-417.
Beds under Denver, Colorado.	....	Tertiary	Hayden......	Report U. S. Geol. Survey, 1867-'68-'69, p. 137.
At exit of South Platte River from mountains.	....	....do	....do	....Do., p. 138.
Near Colorado Springs	....	American Lower Eocene.	Lesquereux...	Report U. S. Geol. Survey, 1873, p. 366.
Hardscrabble Creek, near Cañon City (Cañon City group).	....	Tertiary	Hayden......	Report U. S. Geol. Survey, 1867-'68-'69, pp. 149 to 190.
Near Cañon City.....	....	American Lower Eocene.	Lesquereux...	Report U. S. Geol. Survey, 1873, p. 366.
Coal-beds of Raton Hills (called Raton Hills group).	....	Great Lignite group.	Hayden......	Report U. S. Geol. Survey, 1867-'68-'69, pp. 150 to 190.

Fort Union or Great Lignite group—Continued.

Locality.	Description of strata.	Age.	Authority.	Reference.
Raton beds	....	Cretaceous..........	LeConte	Report Exploration Smoky Hill Railroad route, 1868, p. 66.
Apishpa Creek, Spanish Peaks, and Trinidad, Colorado.	....	Tertiary	Hayden.........	....Do., p. 153.
Raton Pass, Purgatory Cañon.	....	Eocene	Lesquereux...	Report U. S. Geol. Survey, 1871, p. 306.
Raton Mountains ...	....	Lower Eocene	....do	Report U. S. Geol. Survey, 1872, pp. 410–417.
Coal-beds of east edge of mountains in Colorado.	....	Lower Tertiary...	Hayden.......	Report U. S. Geol. Survey, 1867–'68–'69, p. 189.
Fisher's Peak, Raton Mountains.	....	Eocene	Lesquereux...	Supplement to Fifth Annual Report U. S. Geol. Survey, 1871.
Raton Mountains	....	American Lower Eocene.	....do	Report U. S. Geol. survey, 1873, p. 366.
Central and North Colorado.	....	American Lower Eocene.	....do	Report U. S. Geol. Survey, 1873, p. 366.
Lignites of Colorado Basin.	....	....do	....do	American Journal of Sciences and Arts, vol. vii, June, 1874.
		Cretaceous........	Cope..........	Report U. S. Geol. Survey, 1873, pp. 453, 454.
		Upper Cretaceous	J. J. Stevenson	Proceedings of Society of Nat. Hist., city of New York, 2d series, No. 4, 1874, pp. 93, 94. Also "Geological Relations of the Lignitic Groups," read before Amer. Phil. Soc., June 18, 1875.
South Park, northeast of Fair Play.	Sandstones and clays overlying Cretaceous layers.	Lignitic Tertiary	Hayden.......	U. S. Geol. Survey Report of 1867–'68–'69, p. 179. Also Report U. S. Geol. Survey, 1873, p. 38.
Grand River, in Middle Park.	....	Lignitic Tertiary	...do	Report of U. S. Geol. Survey of 1867–'68–'69, p. 183. Also Report U. S. Geol. Survey, 1873, p. 81.
Mount Bross, in Middle Park.	Yellow and gray sandstones and laminated arenaceous clays.	Older Tertiary	....do	Report U. S. Geol. Survey, 1867–'68–'69, pp. 183, 184. Report for 1873, p. 81.
Troublesome Creek and Willow Creek, in Middle Park.	....	Lower Tertiary ...	....do	Report U. S. Geol. Survey, 1873, p. 82.
Troublesome Creek and Mount Bross (Middle Park).	....	American Upper Eocene or Lower Miocene.	Lesquereux...	Report U. S. Geol. Survey, 1873, p. 366.
Middle Park, Mount Bross.	....	Upper Miocene...	....do	....Do., p. 366.
Placer Mountains, south of Santa Fé, New Mexico (Placer Mountain Group).	....	Lower Tertiary ...	Hayden.......	Report U. S. Geol. Survey, 1867–'68–'69, p. 190.
Lignitic beds of New Mexico (at least as far south as Placer Mountain). Anthracite coal.	....	American Lower Eocene.	Lesquereux ..	Report U. S. Geol. Survey 1873, p. 366. Also Amer. Jour. of Sciences and Arts, vol. vii, June, 1874.
Lignite beds of New Mexico and San Juan.	....	Cretaceous.......	Newberry	American Journal of Sciences and Arts, vol. vii, April, 1874, p. 90.

Some of the localities included in the table just given will be given in some of the tables to follow. I will not attempt to account for the discrepancies. I have quoted the opinions relative to the age of the

various beds, as they are given in the reports from which I have taken them.

The next table will include the coal strata of Bear River, Coalville, and Evanston, to which Dr. Hayden (Report U. S. Geol. Survey, 1867-'68-'69, p. 192) gave the name of Bear River group.

Bear River group.

Locality.	Description of strata.	Age.	Authority.	Reference.
Coalville, Utah Territory, and Sulphur Creek.	....	Cretaceous........	Engelmann and Meek.	Proceedings Academy Nat. Sciences, Philada., April, 1860, p. 130.
Bear River City, Evanston, and Coalville.	....	Lower Tertiary, possibly parallel with the older beds of the Great Lignitic Group.	Hayden.......	Report of U. S. Geol. Survey for 1867-'69-'69, pp. 191, 192.
Bear River...........	Sandstones and clays	Tertiary? or Cretaceous?	....do	Report U. S. Geol. Survey, 1870, p. 167.
Coalville and Weber Valley.	....	Upper Cretaceous (No. 5), or Transitional from Cretaceous to Tertiary.	....do	Report U. S. Geol. Survey, 1870, pp. 167, 168.
Coalville, Bear River, and Sulphur Creek.	....	Above Cretaceous, No. 5, Upper Cretaceous.	Meek.........	Report U. S. Geol. Survey, 1870, p. 291.
		Some fossils Cretaceous and some Eoc ne Tertiary.	....do	Do., 296-299.
		Cretaceous........	....do	U. S. Geol. Exploration of Fortieth Parallel, vol. iii, 1870, pp. 464, 465.
Coalville and Bear River.	....	Cretaceous........	Clarence King	Do., p. 458.
Coalville.............	....	Fossils Cretaceous	Meek.........	Report U. S. Geol. Survey, 1871, p. 376.
Evanston coal	....	Eocene	Lesquereux ..	Report U. S. Geol. Survey, 1871, p. 306. Also, Supplement to Fifth Annual Report U. S. Geol. Survey, 1871.
Coalville and Bear River.	....	Cretaceous........	Hayden.......	Report U. S. Geol. Survey, 1872, p. 14.
		Cretaceous	Meek	Do., p. 437.
Sulphur Creek, near Bear River and Coalville.	Alternations of gray and yellowish sandstones and sandy shales, with black, bluish, and reddish clays and beds of coal.	Lower beds Cretaceous, upper beds Lower Eocene?	....do	Do., p. 450.
Upper beds on Sulphur Creek.	Thin seams and layers of dark carbonaceous shales, with harder thin bands of various colored, argillaceous, arenaceous, and calcareous matter, including a very few thin streaks of coal.	Lower Eocene or Upper Cretaceous?	....do	Do., p. 454.
Coalville and Bear River.	....	Cretaceous........	Bannister.....	Do., p. 534.
Coal-beds of Coalville, Utah Territory.	....	Probably equivalent to Evanston coal.	Lesquereux ..	Do., p. 339.
Evanston	....	Upper Eocene....	....do	Do., pp. 410-417.
Coalville and Bear River.	....	Cretaceous........	Hayden.......	Report U. S. Geol. Survey, 1873, p. 97.
		American Lower Eocene.	Lesquereux ..	Do., p. 366.
Evanston	....	American Upper Eocene or Lower Miocene.	....do	Do.
		Cretaceous........	Cope..........	Do., pp. 439-442.

Bear River group—Continued.

Locality.	Description of strata.	Age.	Authority.	Reference.
Evanston coal		Referred provisionally to Fort Union (Cretaceous No. 6).	Cope	Do., p. 441.
Evanston		Half Eocene and half Miocene.	Lesquereux	American Journal of Sciences and Arts, vol. vii, June, 1874.

It seems to be pretty well established that the lower portion of the coal-beds at Coalville and Bear River belong to the upper part of the Cretaceous formation. In this place it is proper to refer to the Judith River beds which Dr. Hayden (Report for 1867–'68–'69, p. 56) placed below the Fort Union group. Professor Meek (Report U. S. Geol. Survey for 1862, p. 460) says, "That the Judith River beds may be Cretaceous, I am, in the light of all now known of the geology of this great internal region of the continent, rather inclined to believe." In an article on some fossils from near the eastern base of the Rocky Mountains, Colorado (Bulletin U. S. Geol. and Geograph. Survey, second series, No. 1, pp. 40, 41), he refers the Judith River beds to the upper part of the Cretaceous. He says, "Whether they may," "in the Upper Missouri country, be distinct enough from the Fox Hills group to form a sixth subdivision of the Cretaceous series, holding a position just above the latter, or whether they ought rather to be regarded as merely an upper member of the Fox Hills group, may admit of some doubt in the present state of our knowledge; though I strongly incline to the latter opinion. It is true, however, that they might really be properly distinct, as a subdivision of the Cretaceous, from the Fox Hills group, and still be so intimately related to the latter that some of their characteristic species of fossils might range down into the same at the Colorado localities (just as some of the Fox Hills types also occur in the Fort Pierre group below, at many localities), without necessarily proving that these two subdivisions should not be treated as distinct rocks."

Whether or not the coal strata at Evanston are equivalent to the coal strata of Coalville cannot yet be positively stated. The consideration of these beds belongs properly to the latter part of the preceding chapter, but as their age was for some time a matter of doubt, I have thought it best to take them up here.

In the next table I present the beds of the Bitter Creek series. Dr. Hayden has considered them Eocene or Transitional. Prof. E. D. Cope called them Bitter Creek (Cretaceous), (Report U. S. Geol. Survey, 1873, p. 435).

Bitter Creek series.

Locality.	Description of strata.	Age.	Authority.	Reference.
Bitter Creek Valley Hallville.	Dark clays, sandstones, slates, and coal-beds.	Lower Eocene or Transitional, from Cretaceous to Tertiary, in part, at least.	Hayden	Report U. S. Geol. Survey, 1870, pp. 75, 76.
Hallville, Black Buttes Station, and Point of Rocks.		Eocene or Transitional.	...do	Do., pp. 164, 165.
Hallville coal mines		Fossils Eocene	Meek	Do., p. 298.
Medicine Bow		Lower Miocene	Lesquereux	Report U. S. Geol. Survey, 1871, p. 304.

Bitter Creek series—Continued.

Locality.	Description of strata.	Age.	Authority.	Reference.
Point of Rocks	....	Fossils above a coal-bed, Cretaceous.	Meek	Do., p. 375.
		Lower Miocene	Lesquereux	Supplement to Fifth Annual Report 1871, U. S. Geol. Survey.
Point of Rocks, Black Buttes, Rock Springs, and Hallville.	Soft, light-yellowish, lead-gray, and whitish sandstones, with seams and beds of various-colored clays, shale, and coal.	Tertiary	Meek	Report U. S. Geol. Survey, 1872, pp. 455–459.
		Aside from the *Dinosaurian* the organic remains favor the conclusion that it (Bitter Creek series) is Tertiary.	...do	Do., p. 461.
Point of Rocks coal-beds.	....	Same age as at Hallville?	Bannister	Do., p. 532.
Black Buttes	....	Lower Eocene	Lesquereux	Do., pp. 410–417.
Black Buttes, Hallville, and Rock Spring.	....	American Lower Eocene.	...do	Report U. S. Geol. Survey, 1873, p. 366.
Point of Rocks, Rock Creek, and Medicine Bow.	....	Middle Miocene	...do	Do.
Black Buttes, and, westward, Rock Spring, Point of Rocks.	Alternating beds of hard and soft sandstones, with argillaceous and carbonaceous strata.	Cretaceous	Cope	Do., pp. 434, 435–439.
Lower Lignite of Black Buttes.	....	American Lower Eocene.	Lesquereux	American Journal of Sciences and Arts, vol. vii, June, 1874.

Waskakie group.

Locality.	Description of strata.	Age.	Authority.	Reference.
Between Creston and Bitter Creek.	Fresh-water beds with some seams of impure lignite.	Middle Tertiary	Hayden	Report U. S. Geol. Survey, 1867–'68–'69, p. 190.
Between La Clede, Barrel Springs, and at Barrel Springs.	Laminated chalky clays; somber, hard, indurated, rusty, arenaceous clays.	Upper part may be an extension of the Bridger group or synchronous with it.	...do	Report U. S. Geol. Survey, 1870, p. 73.
Above coal-beds near Black Buttes.	Indurated arenaceous clays.	Middle Tertiary	...do	Do., p. 71.
Beds above coal-beds, west of Separation and extending to the high hills of Bridger Pass, from the Seminole and Sweetwater ranges.	....	Washakie group	...do	Do., p. 139.
At Separation, and westward from Separation above coal-beds.	....	Miocene	...do	Do., p. 164.
Barrel Springs	....	Fossils Miocene	Meek	Do., pp. 298, 299.
		Fossil plants, Upper Miocene.	Lesquereux	Report U. S. Geol. Survey, 1871, p. 306.
		Fossil plants, (Washakie group,) Lower Miocene.	...do	Do.
		Upper Eocene	...do	Report U. S. Geol. Survey, 1872, pp. 410–417.
		Tertiary	Meek	Do., p. 457.
Separation to Bitter Creek.	....	Upper Tertiary	Bannister	Do., p. 525.
		Middle Miocene	Lesquereux	U. S. Geol. Survey Reports, 1873, p. 366.

As we have already seen, Cope considers the Bitter Creek series Cretaceous. In a letter to me he says, "I have never seen any certain correlation of the Bitter Creek with the other lignite beds, so I call it No. 6, with a question, although it may be a No. 7." Of the Washakie group he says, "I have never studied the Washakie group, and do not know where it comes in." Prof. F. B. Meek (Report U. S. Geol. Survey, 1872, p. 457) says, "In the latter (Washakie group), so far as our present knowledge extends, only fresh-water and land types of fossils have yet been found, and we have always regarded it as being of Tertiary age. Exactly where the one ends and the other begins we did not see." "Between Black Butte and Bitter Creek stations (separated by a distance of only six miles by a right line east and west) we observed no marked change of lithological characters, from the Bitter Creek series to the Washakie group, while the two series seemed to be conformable in dip."

Dr. Hayden (Report U. S. Geological Survey, 1867-'68-'69, p. 190) says, "From Creston to Bitter Creek there is a series of purely fresh-water beds, with some beds of impure lignite, with vast quantities of fossils belonging to the genera *Unio*, *Melania*, *Vivipra*, *Helix*, &c. This group I regard as Middle Tertiary, and the strata are very nearly horizontal. I have regarded these beds as separated from the Lower Tertiary or true Lignite group, and have designated them by the name of the "Washakie group." The Washakie group, therefore, lies above the Bitter Creek series.

Wahsatch group.

Locality.	Description of strata.	Age.	Authority.	Reference.
West of Fort Bridger.	Variegated sands and clays, some shade of red predominating; very little calcareous matter.	Tertiary	Hayden	Report U. S. Geol. Survey, 1867-'68-'69, p. 191.
West of Carter Station, and from Bridger Station to Aspen.	Red, indurated, arenaceous clays, with beds of grayish and reddish-gray sandstone alternating. Pinkish and purplish clays are the dominant features.	Beneath the Bridger group, and probably synchronous with the Green River group.	...do	Report U. S. Geol. Survey, 1870, pp. 147, 148.
Head of Echo Cañon.	Reddish and purplish indurated sands and clays.	Miocene	...do	Do., p. 155.
From Carter Station to the middle of Echo Cañon.	Variegated clays, sands, and sandstones.	Below Bridger group.	...do	Do., p. 168.
	....	On paleontological grounds, synchronous with Green River epoch (Eocene).	Cope	Report U. S. Geol. Survey, 1873, p. 441. Also, Proceedings Acad. Nat. Sci., Phil., 1872, p. 279.

Green River group.

Locality.	Description of strata.	Age.	Authority.	Reference.
East of Rock Spring, and in Green River Valley (Green River shales).	Thinly laminated chalky slates.	Middle Tertiary, above Washakie group.	Hayden	Report U. S. Geol. Survey, 1867-'68-'69, pp. 190, 191.
Near Fort Stambaugh, Sweetwater Valley, Black's Fork of Green River, Big Sandy, and near Granger Station.	Reddish or India-ocher clays, with leaden bands, yellow marls, and rusty drab limestones.	Lower Miocene	...do	Report U. S. Geol. Survey, 1870, pp. 39, 40.

Green River group—Continued.

Locality.	Description of strata.	Age.	Authority.	Reference.
Lower part of Bridger's Butte, and other localities near Fort Bridger.	Limestones and marls.	(Green River beds)	Hayden	Do., pp. 55, 56.
Henry's Fork of Green River.	....	Lower Miocene	...do	Do., pp. 58, 59.
Green River, between Henry's Fork and Black's Fork.	....	Middle Tertiary	...do	Do., pp. 69, 70.
Green River beds	....	(Older than Hayden made them). Eocene.	Newberry	Do., p. 143.
Green River	....	Upper Miocene	Lesquereux	Supplement to 5th Annual Report (1871).
		Probably equivalent of the Eocene Tertiary.	Leidy	Report U. S. Geol. Survey, 1871, p. 353.
		Miocene	Lesquereux	Report U. S. Geol. Survey, 1872, pp. 410–417.
East of Rock Spring	Light, ash-colored beds, succeeded by brilliant colored strata.	Eocene	Cope	Report U. S. Geol. Survey, 1873, p. 436.
Grizzly Buttes, Henry's Fork.	....	Lower Miocene or Eocene.	Marsh	American Journal Science and Arts, vol. iv, 1872, p. 256.
Green River Basin	....	Eocene	...do	Do., p. 299.
Green River	....	Upper Miocene	Lesquereux	Report U. S. Geol. Survey, 1873, p. 366.
		Upper Miocene	...do	Amer. Jour. Science and Arts, vol. iii, June, 1874.
	Shales, marls, and harder calcareous strata.	Lower Eocene	Comstock	Rept. of Reconnaissance of Yellowstone River and N. W. Wyoming, under Capt. Jones, 1875, p. 123.

The Wahsatch group and the Green River group occupy two distinct basins, but are considered synchronous by Dr. Hayden and Prof. E. D. Cope. (See tables of Green River and Wahsatch groups). I shall refer to these groups in another portion of this chapter.

The position of the Wind River group, given in the next table, is by no means certain. It may be equivalent to the Green River formation, as it seems to be above the Lignitic group, or it may represent the Bridger group.

Wind River group.

Locality.	Description of strata.	Age.	Authority.	Reference.
Wind River Valley and west of Wind River Mountains.	Light gray and ash-colored sandstones, with more or less argillaceous layers.	(?) (Beneath White River group).	Hayden	Exploration of Yellowstone and Missouri Rivers, under Capt. W. F. Raynolds, 1859–'60. Geol. Report F. V. Hayden, p. 29.
	Yellowish and light, more or less sandy marls, with pink bands, alternations of sandstones and clays.	(?)	...do	Do., p. 79.
Between Wind River and Big Horn Mountains.	....	(?) Above Lignitic group and under White River group.	...do	Report U. S. Geol. Survey, 1867–'68–'69, p. 57.

Wind River group—Continued.

Locality.	Description of strata.	Age.	Authority.	Reference.
Sweet Water Valley and Wind River Mountains.	Brown indurated sands, with seams of impure lignite or carbonaceous clay, with layers of coarse sandstones.	(?) (Wind River group).	Hayden.......	Report U. S. Geol. Survey, 1870, p. 33.
Between Wind River and Owl Creek.	Marls are frequently variegated, *i. e.*, bands of a bright red or pinkish color are associated with the blue-greenish and light-colored beds.	Resembles the Bridger rather than the Green River beds.	Comstock	Report of Geological Reconnaissance of Yellowstone River and Northwestern Wyoming, under Captain Jones, 1875, pp. 128, 129.

Bridger group.

Locality.	Description of strata.	Age.	Authority.	Reference.
West of Bryan and at Church Buttes.	Fine sands and sandstones, mostly indurated, sometimes forming compact beds, but usually weathering into castellated and dome-like forms, like the Bad Lands of White River.	Upper Tertiary ...	Hayden.......	Report of U. S. Geol. Survey, 1867-'68-'69, p. 191.
Capping the Green River beds in places between Big Sandy and Black's Fork of Green River.	Leaden-gray indurated arenaceous clays.	Above Green River group.	....do	Report U. S. Geol. Survey, 1870, p. 40.
Between Fort Bridger and the Uintah Mountains.	....	Miocene...........	....do	Do., p. 42.
Bridger's Butte, near Fort Bridger, and divide between Smith's Fork and Henry's Fork of Green River.	Somber-brown indurated arenaceous clays, gray and rusty-brown sandstones; leaden-brown clays.	Bridger group.....	....do	Do., pp. 55, 56.
Between Smith's and Henry's Forks of Green River and in Green River Valley.	Indurated clays; intercalated with the clays are beds of rusty-brown and gray sandstones, all tending to a concretionary structure.	Above Lower Miocene beds.	....do	Do., pp. 58, 59.
Church Buttes	Brown indurated sands and clays.	Middle Tertiary, probably synchronous with White River beds.	....do	Do., pp. 144, 145.
		Fossils, Miocene ..	Meek	Do., pp. 298, 299.
Echo and Weber Valleys.	Conglomerates......	Probably parallel with Bridger group (Upper Miocene).	Hayden	Do., p. 168.
Near South Bitter Creek at La Clède.	....	Upper Miocene ...	....do	Do., p. 75.
		Eocene............	Cope	Report U. S. Geol. Survey, 1873, p. 437.
Henry's Fork and Muddy Creek.	....	Upper Miocene ...	Lesquereux ...	Report U. S. Geol. Survey, 1871, p. 306.
	Dull-colored indurated clays and brownish, dull-yellow, or gray arenaceous layers, with more or less concretionary structure.	Upper Eocene	Comstock	Report of Reconnaissance of Yellowstone River and Northwestern Wyoming, under Captain Jones, 1875, p. 127.

White River group.

Locality.	Description of strata.	Age.	Authority.	Reference.
On White River, under Loupe River beds, and on the Niobrara River, and across to the Platte River.	White and light-drab clays with some beds of sandstone, and local layers of limestone, and whitish indurated clays.	Miocene	Hayden	Geol. Report of Exploration of Yellowstone and Missouri Rivers, by Dr. F. V. Hayden, under Capt. W. F. Raynolds, 1859–'60, p. 29; also Report U. S. Geol. Survey, 1867–'68–'69, p. 57.
On White Earth Creek and White River.	Variegated beds, cream-colored, reddish-brown, and light-gray sands and marls.	...do	...do	Exploration of Yellowstone and Missouri Rivers, p. 134.
In the valley of the Chug-Water, on Horse Creek, and on the North Platte.	Light-colored marls and sands.	White River Tertiary.	...do	Report U. S. Geol. Survey, 1867–'68–'69, p. 80.
Beds beneath Cheyenne.	....	...do	...do	Do., p. 110.
On the Chug-Water and Crow Creek.	....	...do	...do	Report of U. S. Geol. Survey, 1870, pp. 13, 15.
Along the North, and on La Bonte and Horseshoe Creeks.	....	...do	...do	Do., pp. 19, 20, 23.
Fort Fetterman	....	...do	...do	Do., pp. 23, 24.
100 miles northwest of Fort Laramie.	....	...do	...do	Do., p. 121.
		Miocene	Leidy	Report U. S. Geol. Survey, 1871, p. 353.
Plains west of Cheyenne.	Drab, yellow, and light-gray sandstones, marls, and clays.	Miocene (?)	Hayden	Report U. S. Geol. Survey, 1873, p. 17.
		Miocene	Cope	Do., p. 461.

The "Monument Creek" and the "Gallisteo Sand" groups deserve mention here. The latter has been referred to the Miocene by Dr. Hayden (Report U. S. Geol. Survey, 1867–'68–'69, pp. 139, 167, 190.) It consists of "variegated sands and sandstones, and light-reddish brick-red, purplish, yellow-white, brown, and drab, with irregular layers of dull rusty-brown concretionary arenaceous limestones." It will be noticed that this description resembles those already given for the Green River and Wahsatch groups.

In the report of U. S. Geol. Survey, 1867–'68–'69, p. 139, 140, Dr. Hayden points out the resemblance of the Monument Creek group to the Gallisteo Sand group, and to the beds between Fort Bridger to Weber Cañon (Wahsatch group), and refers it to Late Miocene or Pliocene. He makes the same reference in the report for 1870, p. 161. In the report for 1873, page 33, he refers it to Miocene. In Bulletin No. 3, Second series, he refers it to the Lignitic group, but in Bulletin No. 4, p. 219, he corrects this statement. Prof. E. D. Cope (Report U. S. Geol. Survey 1873, p. 430) says: "The age of the Monument Creek formation in relation to the other Tertiaries not having been definitely determined, I sought for vertebrate fossils. The most characteristic one which I procured was the hind leg and foot of an *Artiodactyle* of the *Oredore* type, which indicated conclusively that the formation is newer than the Eocene. From the same neighborhood and stratum, as I have every reason for believing, the fragment of the *Megaceratops coloradoensis* was obtained. This fossil is equally conclusive against the Pliocene age of the formation, so that it may be referred to the Miocene, until further discoveries enable us to be more exact."

The columns on the opposite page are summarized from the tables that have already been given:

		Hayden.	Lesquereux.		Cope.	Comstock.		
						West North America.		Western Wyoming.
Miocene.	Upper Miocene.	White River group; Bridger group.	Green River group; coal of Elko Nev.; South Park, near Florissant, and Castello's ranch; Middle Park.		White River group.	White River group, &c.		Wind River and Sweetwater groups.
	Middle.	Wind River group. ?	Carbon coal; Washakie group. Medicine Bow, Point of Rocks, Rock Creek, } Part of Bitter Creek series.					
	Lower.	Wahsatch group; Green River group.	American Upper Eocene.	Evanston; Mount Bross.				
Eocene.	Ft. Union group.	Upper Missouri region; Colorado and New Mexico coal-basins; carbon coal; separation.	American Lower Eocene.	Raton Mountains; Cañon City; Basin of Central and Northern Colorado. Black Butte, Hallville, Rock Spring, } Part of Bitter Creek series. Coalville and Bear River; New Mexico lignites.	Bridger group.	Upper Eocene.	Uintah basin beds.	Bridger group.
	Transitional, or Eocene.	Bitter Creek series.			Green River group.	Part or whole of Ft. Union or Great Lignite group.		Green River beds.
Upper Cretaceous.	No. 5.	Coalville and Bear River; Fox Hills group.	Fox Hills beds.		No. 6.—Bitter Creek, Ft. Union, and Bear River. No. 5.—Fox Hills.	Fox Hills group.		Green River coal group.

It will be seen, on referring to the column headed Lesquereux, that beds of the Bitter Creek series are in part under Miocene, and in part under Eocene. The reason of this may be that the specimens are from different horizons, or, if from the same horizon, it would seem to prove that there is a mingling of forms in the flora of Eocene and Miocene formations. It is probable that when more complete collections are made, this will be found to be the case. That the coal-beds of these localities, however, belong to the same horizon is evidently the opinion of Dr. Hayden and Prof. F. B. Meek, who have studied the localities stratigraphically. (See references in tables).

LIGNITIC GROUP.

West of the continental divide the coal-bearing strata are not confined to the Lignitic group (as named east of the mountains). As noted in the preceding chapter, I found lignite in the sandstones of the Dakota group. In 1873 Mr. Marvine* found a "thin seam of coal" "a few hundred feet above the quartzitic sandstones of No. 1," at the "Hot Springs" in Middle Park. During the season of 1874 Mr. Marvine found coal in a horizon above fossils of No. 4 and below those referable to No. 5. Dr. Endlich, in his district, recognized three distinct lignitic layers in different horizons of the Cretaceous formation. The coal of the Elk Mountains is probably of the age of the Fox Hills group. I have already referred to the possibility of the upper part of the series there, in which the coal is found, being a part of the Lignitic group, but, until fossils are found, I refer it to Upper Cretaceous.

Professor Newberry † found lignite in Lower Cretaceous and in Jurassic strata in Northeastern Arizona. In Minnesota, also, coal has been found in Lower Cretaceous rocks.

The reason of the differences of opinion as to the age of the disputed beds called lignitic seems to be that there are two sets of lignite-bearing beds close together, one belonging to the horizon of the Fox Hills beds of the Cretaceous or possibly a little above it, and the other belonging to the horizon of the Fort Union group (Lower Eocene). As Prof. G. M. Dawson ‡ says, "An observer beginning his study of the beds on their eastern margin, and proceeding westward, as Dr. Hayden has done, would be completely justified in placing the whole series, at least down to the top of Cretaceous No. 5, in the Tertiary; while a geologist familiar in the first instance with the fossils of the underlying Cretaceous formations, and following the lignite strata eastward from their appearance in the Rocky Mountains, would in all probability include the whole series in the upward extension of the Cretaceous, though doubts might begin to assail him before he reached the upper or most eastern beds."

In many places the coal of the upper part of the Cretaceous appears to be absent. When present the sandstones have a transitional character, but this is also noticed where coal is found in the lower part of the Cretaceous formation, and in the Jurassic, just beneath. Professor Cope refers the lignite-beds to the Cretaceous formation from the discovery of the reptilian fauna in them. He has described a *Dinosaurian* reptile from the Bitter Creek series,§ and also from the Fort Union group in Colorado.|| Professor Meek ¶ says, "Aside from the *Dino-*

* Report of U. S. Geol. Survey, 1873, page 156.
† Colorado Exploring Expedition, Geological Report, pp. 83, 85.
‡ Geological Report on the Region in the Vicinity of the Forty-ninth Parallel, p. 202.
§ Proceedings of the American Philosophical Society, 1872, p. 482.
|| Report United States Geological Survey of the Territories, 1873, p. 441.
¶ Report United States Geological Survey, 1872, p. 461.

saurian, the organic remains favor the conclusion that it (Bitter Creek series) is Tertiary." Professor Lesquereux, from the study of the flora as we have already seen, refers the beds to the Eocene period. Cope, in his conclusion, (Report United States Geological Survey, 1873, p. 447), says there is, then, no alternative but to accept the result that a Tertiary flora was contemporaneous with a Cretaceous fauna, establishing an uninterrupted succession of life across what is generally regarded as one of the greatest breaks of geologic time.

I insert here a letter from Prof. Theodore Gill, on the value of the *Dinosaurian* remains, as proof of the Cretaceous age of the strata in which they are found:

SMITHSONIAN INSTITUTION,
Washington, January 9, 1876.

DEAR SIR: Your letter, requesting a copy of my communication to the meeting of the National Academy of Sciences respecting the values of fossils as indices of formations, has duly come to hand.

My remarks were not published otherwise than in brief newspaper reports. They were elicited by the controversy then prevailing respecting the age of the lignite-beds in which the *Dinosaurian* remains, to which you allude, were found. The substance of my criticisms was that we should not be too much influenced in our views as to the age of any group by one or two including fossils; and I brought up a number of cases to show how mistaken we should be if we allowed ourselves to be too much influenced by what was known of the paleontology of any limited country. Among other instances, I especially alluded to the fact that for a long time the fish, genus *Ceratodus*, was regarded an indication of a not later than Triassic age of any including formation; and showed that while such is the case for the northern hemisphere, so far as yet has been observed, we still have living *Ceratodi* in the southern hemisphere, not long ago discovered. I proceeded then to show the close relation between the species of this group, which lived in Triassic Europe, and the species which live in modern Australia. I further indicated that the remains of *Agathaumas*, found in the lignite-beds, were not sufficiently characteristic to enable us to determine the exact relationship of the genus, and that it was apparently not, at least nearly, allied to any of the previously recognized forms of the order. The conclusion was drawn that inasmuch as the same typical structure could persist and had persisted, with shifting geographical relations, through such long ages as had *Ceratodus*, that in the case of the *Dinosaurians*, where the affinities were less intimate, there could be no *a priori* reason why they might not have had a similar history. It was in fact assuming the premises in dispute to assert that because the remains of the *Dinosaurian* were found in a given horizon they must necessarily indicate Mesozoic age, notwithstanding the other associated fossils. I finally urged that in this case, where the evidence was conflicting, we would have to wait for further proof from other quarters, and especially for the tracing of definite horizons toward, and co-ordination with, those above and below the beds in dispute.

I adduced a number of other facts bearing on the subject; but this will be sufficient to show the drift of my argument and the evidenee of the facts set forth.

Hoping that this epitome will answer your purpose, I remain, yours truly,

THEO. GILL.

Dr. A. C. PEALE.

Cope also says,* "The appearance of mammalia and sudden disappearance of the large Mesozoic types of reptiles may be regarded as *evidence of migration, and not* of creation. It is to be remembered that the smaller types of lizards and tortoises continue, like the crocodiles, from Mesozoic to Tertiary time without extraordinary modification of structure. It is the *Dinosauria* which disappeared from the land, driven out and killed by the more active and intelligent mammal; herbivorous reptiles like *Agathaumus* and *Cionodon* would have little chance of successful competition with beasts like the well-armed *Bathmodon* and *Metalophodon*." If the smaller types persisted, why not the larger? The only reason he gives is that they would have little chance of successful competition with the well-armed mammals. Why should this not

* Report United States Geological Survey, 1873, p. 442.

apply also to the smaller? He says also that paleontology confirms Hayden's conclusion that there is no evidence of any catastrophe sufficient to account for any sudden and complete destruction of life. The change from marine waters to fresh water accounts for the destruction of the marine invertebrate life, but, as Hayden* says, "the vertebrates of the Lignitic period having great powers of locomotion, and being able to live on land as well as in the lakes and marshes of that time, and as we have shown that there was at no time any important catastrophe or physical changes sufficient to affect them, could well have prolonged their existence far up into the Lignitic group, carrying with them as an inheritance their Cretaceous characters." No one form of life should be taken as a basis of classification. Cope's comparative list of vertebrate species,† under Colorado and Dakota, includes two species of *Plastomenus*, a Tertiary genus, although in a foot-note he says he so refers them provisionally. The fauna, therefore, even according to his own list, is not exclusively Cretaceous. Writing to Prof. G. M. Dawson on some remains found in the lower portion of the Lignitic formation on the forty-ninth parallel, he says:‡ "This is a characteristic collection of the reptiles of the Fort Union Cretaceous, but with increased admixture of Eocene forms. *Plastomenus* is an Eocene genus, but the reference of the new species to it is not final. But you send two Eocene gar scales which have every appearance of belonging to the same formation. Will you re-examine your notes to inform me whether they really belong to the same horizon as the others?" Dawson says:§ "The gar scales referred by Professor Cope to the genus *Clastes*, were obtained at the very base of the Lignitic formation and below the lowest lignite-bed." "*Dinosaurian* bones occurred within a few feet of them."

We have already seen that the coal-bearing strata at Coalville and Bear River are undoubtedly Cretaceous. The only reason to be given for including the different groups in one formation is the fact of the presence of coal; and we might, then, include all coal-bearing strata, whether Carboniferous, Triassic, Jurassic, Cretaceous, or Tertiary, in the same. In this case the lignitic strata are very close together; and in fact one immediately succeeds the other. This is also the case at the base of the Cretaceous in some places. Professor Newberry,‖ referring to a bed of lignite of Jurassic age in Northeastern Arizona, says: "The sandstone, shales, and limestone lying above, also include many beds of lignite closely resembling this, and on lithological grounds would appropriately be grouped with it. In fact they have been considered Jurassic, and the only Jurassic rocks in this region, by the geologist Marcou, who claims to have discovered the representative of this formation in New Mexico. Unfortunately, however, for that classification, immediately over the thin stratum of yellow sandstone which overlies the coal, are beds of clay shale, with bands of limestone in which are unmistakable Cretaceous fossils." Plants of the lignite above were dicotyledonous, while those found below "are closely allied to some of those most characteristic of the Jura and Upper Trias of Europe."¶ The base of the Cretaceous formation is therefore seen to resemble the base of the Tertiary. In Eastern Colorado the upper part of the Cretaceous is destitute of coal. In fact the Upper Fox Hills group is wanting in many localities, and

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* Notes on the Lignitic group of Eastern Colorado and portions of Wyoming, Bulletin No. 5, second series, United States Geological Survey of Territories, p. 411.
† Report U. S. Geol. Survey of Terr., 1873, p. 433.
‡ Geol. Report Forty-ninth Parallel, p. 200.
§ Ibid.
‖ Ives's Colorado Expedition, Geological Report, p. 83.
¶ Ives's Colorado Expedition, Geological Report, pp. 83, 85.

sometimes the Lignitic group rests on No. 4 or No. 3 Cretaceous.* I have already (page 145) referred to the equivalence of the Judith River beds and some strata at the eastern base of the Rocky Mountains, west of Greeley and Evans, Colo. The fossils upon which Professor Meek predicated this equivalence "came from the very upper beds of well-defined marine Cretaceous, and below the horizon of all the coal-bearing strata of the Colorado region."†

In the report of United States Geological Survey for 1872, p. 459, Professor Meek speaks of the resemblance of some of the fossils from the Black Butte and Point of Rocks localities, to some species found in the brackish-water beds at the mouth of the Judith River. They would seem, therefore, to be equivalent to those seen east of the mountains west of Greeley. He says they are distinct from any found at Coalville or Bear River. In speaking of Black Butte it must be remembered that there is also a Black Butte station at which the beds are probably not of the same horizon. Point of Rocks, Hallville, and Rock Spring are not all of the same horizon. In going from Table Rock to Salt Wells (see report of H. M. Bannister, U. S. Geological Survey, 1872, p. 524), we go down through a fresh-water series to brackish-water beds and finally to marine Cretaceous at Salt Wells, which is in an anticlinal. Speaking of the coal horizon of Point of Rocks, Bannister says:‡ "It seems almost too low in geological position to be referred to the horizon of the Hallville beds, although it may occupy the same." Meek, in the report for 1872, p. 458, refers them to the same horizon, although in the report for 1871 he refers Point of Rocks to the Cretaceous and Hallville to the Eocene, from the affinities of the fossils.

Until the stratigraphy of the region is thoroughly investigated there must remain some little doubt. Professor Meek, in his table of fossils of the Bitter Creek series,§ evidently considers the Point of Rocks locality at the lower part of the series. Professor Meek‖ has identified some fossils from two hundred miles east of Greeley, Colo., as the same that are found over one of the coal-beds at Hallville, Wyo., and at Black Butte Station, Utah. He says: "That the formation from which these fossils came, however, is the same as the Bitter Creek series of Wyoming, including the Black Butte beds, the Hallville coal-mines, Point of Rocks, and Rock Spring coal-mines, &c., I have scarcely a shadow of doubt."

It remains now to state the following conclusions:

1. The lignite-bearing beds east of the mountains in Colorado are the equivalent of the Fort Union group of the Upper Missouri, and are Eocene-Tertiary; also, that the lower part of the group, at least at the locality two hundred miles east of the mountains, is the equivalent of a part of the lignitic strata of Wyoming.

2. The Judith River beds have their equivalent along the eastern edge of the mountains below the Lignite or Fort Union group, and also in Wyoming, and are Cretaceous, although of a higher horizon than the coal-bearing strata of Coalville and Bear River, Utah. They form either the upper part of the Fox Hills group (No. 5) or a group to be called No. 6.

3. That the upper part of the Fox Hills group is wanting in many parts of Eastern Colorado, and when present seems to be thin and destitute of coal.

* Hayden Bulletin No. 5, 2d series, U. S. Geological Survey of the Territories, p. 404.
† Bulletin No. 1, 2d series, U. S. Geological Survey, p. 40.
‡ Report U. S. Geological Survey, p. 532.
§ U. S. Geological Survey, p. 477.
‖ Bulletin No. 1, 2d series, p. 42.

TERTIARY BETWEEN GRAND AND GUNNISON RIVERS.

The only portion of the district in which Tertiary rocks are seen is in the region between its two main streams. I have no absolute proof that the Lignitic group is present. At all the localities I visited, the intermediate beds from the upper part of the Fox Hills beds to the red sandstone bed that I took as the base of the Green River and Bridger series were covered. The Lignitic group may include a portion of the beds above and a part beneath. It is impossible to define any line of separation. Although I could see no unconformability between the Cretaceous and overlying Tertiaries, it is probable that in other places evidences will be found, especially on the edges of the Tertiary basin. In a conglomeritic sandstone on Plateau Creek I found an inner convolution of a *Scaphite*. It was a pebble, and proves that the layer in which it was found, is of Post-Cretaceous age, its materials coming from the disintegration of Cretaceous rock which were above water-level when the stratum was deposited.

GREEN RIVER AND BRIDGER GROUPS.

I shall use the name Green River group to include also the Wahsatch group of Hayden. Cope restricts the name to the Green River shales. Whether we call them Eocene or Miocene depends upon the view we take of the beds below. The vertebrate palentologists consider them Eocene, while all who hold to the Tertiary age of the Lignitic group place them in the Miocene.

As has already been stated, the greater portion of the Tertiary beds exposed in the district is referable to the Green River and Bridger groups. These strata are seen between the Grand and Gunnison rivers, west of Roaring Fork, and are almost horizontal, dipping slightly to the eastward beneath the basaltic-capped plateaus, which are fully described in other portions of the report. The area is shown on map E.

The characters of the included rocks will be given as we proceed. The best exposures are seen on Plateau Creek, a branch of the Grand River, which joins it some distance above the mouth of the Gunnison, after cutting deeply into the strata. The following section will give the best idea of the succession of the strata on Plateau Creek.

No. 19.—*Section of Tertiary Beds.—Plateau Creek.*

	Base.		Thickness Ft. In.
1.	Red sandstone		2,000 0
2.	Yellow and white sandstones		
3.	Red sandstone, 30 feet		
4.	Variegated red, yellow, and bluish marls, sandstones, and clays		
5.	Bluish and black argillaceous beds		
6.	Yellow sandstone		
7.	Black argillaceous beds		
8.	Brownish red sandstone		
9.	Soft greenish argillaceous shales		
10.	Green sandstone shales		
11.	Black argillaceous shales		
12.	Massive sandstones in pinkish-white and yellowish-gray layers, with interlaminated greenish shales. Some of the layers are conglomeritic	250	
13.	Dark greenish shaly sandstone		
14.	Series of soft variegated beds, yellow, reddish, and black, much like those given in lower part of this section. They are generally concealed, but where exposed the *débris*, from the softness of the strata, makes it almost impossible to get the section in detail. Thickness about		740 0

Base.	Thickness. Ft.	In.
15. Space probably filled with soft yellowish sandstones and interlaminated red and green shales and marls, a continuation upward of No. 14	170	0
16. Soft, grayish-white sandstone	46	0
17. Red and greenish shales	23	0
18. Gray sandstone	3	0
19. Greenish-gray sandstone	8	3
20. Red shales, passing up into green	3	6
21. Yellow sandstone, covered near the top, having in all probability interlaminated shales	75	0
22. Yellow sandstone	48	0
23. Red and greenish-gray shales, probably calcareous, especially in the red layers. At the top the layers weather into rounded masses looking like concretions; the lower beds are covered with *débris*. The red layers are from one foot to 2 feet in thickness, while the green are from 18 inches to 2½ feet. They are rather irregular, however, the colors fading out in places	45	0
24. Massive, coarse-grained yellow sandstone, with angular fracture breaking into large square blocks	90	0
25. Greenish argillaceous and sandy shales in laminæ of an inch or less thickness	22	0
26. Massive yellow sandstone like that of No. 24	11	0
27. Shales like those of No. 25	24	0
28. White, red, and yellow sandy argillaceous and gypsiferous beds	38	4
29. Yellow sandstone resembling that of No. 24 and No. 26, except that it is not quite so massive, and is gypsiferous	5	0
30. Yellow sandstone, conglomeritic at base, then shaly, and finally massive	14	0
31. Argillaceous and sandy shales, greenish, and in fine laminæ below, becoming reddish above	3	0
32. Massive yellow sandstone	6	0
33. Micaceous sandstones and shales, with a band of massive sandstone, 20 feet thick, in the center. The shaly layers are fossiliferous, containing fragments of bones	100	0
34. Red and greenish sandstone, weathering into rounded masses	10	0
35. Green and red sandstone shales with intermediate bands of sandstone	46	0
36. Red and yellow mottled, rather massive, sandstone, weathering in rounded masses	5	0
37. Hard dark-greenish sandstone } 38. Red irregular sandstone }	30	0
39. Soft shaly sandstones with fragments of *bones*	13	2
40. Massive sandstones	9	10
41. Shaly sandstones with fragments of *bones*	57	0
42. Yellow sandstones with bones imbedded	9	0
43. Yellow sandstones, somewhat shaly below but becoming more massive toward the top, especially in the upper five feet	34	6
44. Argillaceous and sandy shales with fragments of bones	3	0
45. Greenish and reddish sandstones, somewhat argillaceous, weathering in bowlder-like masses	12	0
46. Massive sandstones	12	0
47. Greenish sandstone, like No. 45	10	0
48. Massive yellow sandstone	50	0
49. Greenish and yellow shaly sandstones, with fragments of *bones*	150	0
50. Massive yellow sandstones, with imbedded bones, especially abundant in the lower part	10	0
51. Coarse, soft, gray, shaly sandstones	50	0
52. Massive yellow sandstone	6	0
53. Greenish-gray sandstones, mostly laminated, some of the layers having mud-marks on the surfaces	100	0
54. Coarse yellow sandstones in massive layers } 55. Soft gray sandstones with numerous fragments of *bones* }	75	0
56. Soft and hard gray sandstones with interlaminated shales, calcareous and argillaceous, reaching from the top of layer No. 55 to the base of the white bluffs below station 50. The total thickness is about	1,600	0
57. Alternations of dark-gray indurated clay beds, weathering white, and arenaceous layers reaching to the summit of station No. 50. Many of these layers are probably calcareous. Gypsum does not seem to be as abundant as in the lower layers of the section. I did not have time to make a detailed section. The total thickness is about	1,000	0
Top.		
Total thickness	6,767	7

This section does not give the total thickness of the beds, as it only reaches to the summit of station 50. The summit of the plateau beneath station 48 has about 800 or 900 feet more of beds similar to those given in the section above, under No. 57. Even this thickness, about 7,670 feet in all, may not represent the entire original thickness, for we cannot at present tell the exact amount of erosion preceding the pouring out of the basaltic covering of the two plateaus.

The following section is summarized from Professor Cope's report in the Annual Report of the United States Geological Survey for 1873, pp. 436, 437.

Wahsatch formation (Green River group).

	Thickness in feet.
1. Ash-colored banks, with bones of a mammal allied to the Bridger *Hyopsodus*, or *Hyracotherium* of the Eocene of Europe and a number of *Paludina*-like shells, followed by light ash-colored beds exposed in banks, with bones of Green River vertebrata. Near the top is a thin bed of lignite	140
2. White bluffs, terminating in a high escarpment	100
3. Thin bed of buff clay and sand-rock, with numerous shells and scattered teeth and scales of fishes	
4. White bluffs	100
5. Brilliantly colored strata extending in horizontal bands. They are brilliant cherry red, white, true purple, with a bloom shade, yellow, and pea-green. The lower portions are bright red and contain remains of *Emys euthnetus*, Cope, and some borings of a worm	400–500
6. Muddy-yellow clays and slate-rocks	200
7. White or ashen beds, with decayed remains of mammals and turtles, also buff sandstones	50
Bridger group.	
8. Mammoth buttes; sediments with numerous mammalian remains	1,000
Total thickness	2,090

The resemblance of the beds I have given in section No. 19 will be seen at a glance. The following table of comparison will give the relations of the two sections:

Section No. 19, A. C. Peale.	Thickness.	Prof. E. D. Cope's section.	Thickness.
Layers Nos. 1 to 55, inclusive	4,170	Wahsatch formation, (Nos. 1 to 7, inclusive)	1,090
Layers Nos. 55 to 57 inclusive, with the 900 feet of additional beds not given in the section	3,500	Bridger group, (No. 8)	1,000
Total	7,670	Total	2,090

It will be noticed that the thickness on Plateau Creek is much greater than that given in Professor Cope's section. Comparing section No. 19 with the descriptions given in the tables (page) we see the similarity in composition of the strata. The fossils obtained could not be positively identified as to whether they were from the Green River or Bridger groups.

The bones from the layers, Nos. 33, 39, 41, 44, 49, 50 and 55, of the section No. 19 were submitted to Prof. E. D. Cope for examination. He says they are "undoubtedly Eocene (Bridger or Green River). I find species of reptiles and fishes; the former *Crocodilus*, *Emys*, and *Trionyx*; the latter *Pappichthys*."

The beds given in the lower part of the section are probably of the same horizon as the Green River group, as I have shown in the table, while those above represent the Bridger group. It is impossible at present to tell any more definitely the line that separates them.

The following is the description given by Dr. Hayden* of the Green River group, as exposed in the valley of Green River: "The laminated calcareous shales gradually pass down into yellow-gray and brown indurated clays, sands, and sandstones, until the well-defined coal-strata are exposed without the least appearance of discordancy." In other portions of the report for 1870, he gives descriptions of the Green River group, and speaks of their being worn into towers and other picturesque forms. Prof. Theo. B. Comstock † gives the following description: "The Green River beds are mainly composed of a series of shales, marls, and harder calcareous strata." "The texture of the different beds is quite variable, but in general the streams which have cut their channels through them are walled by nearly vertical cliffs, and the buttes and benches for the most part have quite precipitous sides. Numerous joints occur in many of the strata, particularly in the more compact kinds, and fine examples of concretionary structure or weathering are not rare. The tendency of the thick beds of marly sandstone on the banks of Green River, at the crossing, to weather spheroidally is very noticeable, and this is repeated in various degrees in the argillaceous and calcareous rocks as well." In regard to the Bridger group he says,‡ "The beds of the Bridger group, as a whole, are readily distinguishable from those of the Green River group, being mainly composed of dull-colored indurated clays and arenaceous layers of considerable thickness, the latter usually brownish, or dull yellow or gray, often with more or less of a concretionary structure." Dr. Hayden (see Report of 1870) gives the same general description. I have quoted these descriptions to show the resemblance of the strata given in the section made on Plateau Creek to the strata found farther north. A comparison shows the same general characters, even to the spheroidal weathering of some of the layers. Although the beds included under layer No. 57 of the section correspond to the description quoted above of the Bridger group, their identity is by no means certain. Another season I hope to obtain more evidence on the question. These beds form the cliffs immediately beneath the plateau of station 48, and are prominent from a great distance, on account of their white color. They also outcrop in the cliffs on the north side of the Grand opposite the plateau and extend far to the northward. They are also seen far to the westward and southwestward, between the Colorado and Little Colorado or Chiquito Rivers. In this region they are thus referred to by Professor Newberry:§ "Some miles north of camp 96 (*situated about latitude* 36°, *longitude* 110° 45′) a mesa wall rises to a height which we estimated at something like twelve hundred feet. It occupies 30° of the horizon in that direction, and shows bold, nearly perpendicular faces both in profile and in front. These are pure white in color and reflect the sunlight like sun." "Rising, as it does, so distinctly from the mesa of Lower Cretaceous, but two formations are left in the series of which it could be composed, Upper Cretaceous and Tertiary." These bluffs are probably a portion of the same strata that form the bluffs on the Grand and beneath the plateau of station 48. Professor Newberry did not have an opportunity to examine them, but

* Report U. S. Geol. Survey, 1870, page 71.
† Report upon Reconnaissance of Northwestern Wyoming, 1873, pages 123, 124.
‡ Report upon Reconnaissance of Northwestern Wyoming, 1873, page 127.
§ Ives's Colorado Exploring Expedition, Geological Report, page 87.

considered them to be of Upper Cretaceous rather than Tertiary age. He says, "There are some reasons, however, why we should suspect this white mesa to be Upper Cretaceous rather than Tertiary, and these are, first, that all the Tertiary rocks of the Rocky Mountain country, as far as they have been examined, are of fresh-water or estuary origin, have been usually deposited in basins of less extent and depth than would be indicated by this great plateau, which has evidently been greatly reduced in dimensions by the erosion it has suffered; second, the materials composing the Tertiary strata found on the great central plateau are generally soft, and yield readily to the action of the elements, presenting rounded and unbroken outlines or pinnacles and deeply channeled surfaces, the results of erosion. On the contrary, the Upper Cretaceous strata, as they appear in several points on our route, holding precisely the relative position of the white mesa to the Lower Cretaceous sandstones, consist of a series of shales and limestones which, though dark internally, weather to an almost chalky whiteness, and yet are as resistant to atmospheric erosion as any other sedimentary rocks. Judging from the view we had of it, we regarded the white mesa as continuous with the white mesa bordering the Colorado, which has about the same altitude. If so, the strata composing it must occupy a very large area north and west of our camp 96, one almost too large to accord with the supposition that it is of Tertiary age."

My reasons for referring the strata of section No. 19 to the Tertiary are, first, the finding of vertebrate organic remains identified by Professor Cope as of Eocene age; and, second, the lithological identity to the beds farther north, in which Marsh, Cope, and Leidy have found so many vertebrate remains identified by them as of Eocene age.

As already noticed in the preceding chapter, the strata included in the Upper Cretaceous weather very white, although they do not show so prominently as the upper portion of those given in section No. 19. It is impossible at present to define the exact limits of the basin in which these layers were deposited. As mentioned in preceding parts of this report, the Sawatch range was probably partially above water in Cretaceous and Pre-Cretaceous times. It probably formed a part of the eastern shore of the ancient lake, although all traces of the beds along its western flanks have been entirely removed. To the northward it was probably connected with the Green River Basin. Prof. T. B. Comstock,* speaking of the Green River group, says, "There are indications that its eastern boundary was outside of the present limits of the Green River Basin, and there is no room for doubt that the Uintah Mountains and the Wasatch chain, then as now, towered above its surface. Northward it is equally clear that the Wind River range formed the shore of the great lake, with probably more or less of gently sloping border, during a portion of the era of Lower Eocene deposition." Before we can decide definitely as to the connection of the strata of the Green River Basin with those noted between the Grand and Gunnison Rivers, the country north of the Grand will have to be examined. What the southern and southwestern limits of the lake were, it is impossible to say at present. Enough has been said to prove its vast extent in that direction. The investigations of the next season's work will probably throw considerable light upon the subject.

Professor Marsh discovered evidence of a basin south of the Uintah Mountains, about the mouth of the White River. This is probably the direct extension of the basin I have described. Professor Marsh thinks

* Report upon the reconnaissance of Northwestern Wyoming, p. 123.

that although synchronous with the Green River Basin, that the lakes were connected only as our great lakes are at the present day, by narrow straits.

POST-TERTIARY AND RECENT.

Glacial.

In the Sawatch range, as was fully detailed in the reports for 1873, there is abundant evidence of glacial action. The moraines in the cañons at the head of Eagle River have been already described. It is impossible, with the present limited amount of data, to define what were the limits of the glaciers. It is probable they were more widely distributed than has been generally supposed. It is possible that a glacier once covered the plateau of station 48, and the one to the south. The erosion on these plateaus could scarcely have been effected by any other agency. There are several lakes on the surface which may have had their origin in glacial action.

Farther north Mr. Marvine found evidences of glaciation on similar plateaus, capped with basaltic lava. They were, he thinks, at a higher level, and when he descended, the traces ceased. The Roches-Moutonnées forms were very prominent.

Terraces, etc.

Eagle River.—In the valley of the Eagle, above the second cañon, extending almost to the mouth of the Piney, are terraces cut in drift. Whether this drift is stratified or unstratified I am unable to say. It is, I think, in part at least, of glacial origin. The terraces here are about 100 feet high. Below the cañon there are beautiful terraces, as shown in section D, Plate III. These are comparatively recent. The soft character of the strata in the valley renders them easily eroded, and even at the present time an immense amount of material is carried down the river every spring. Alluvial material occurs at various points along the course of the river, especially above the second cañon, where the river has some lake-like expansions surrounded by beautiful meadows.

Grand River.—A great portion of the Grand River is a cañon, but below the mouth of Roaring Fork, especially near the plateau of station 48, there are terraces. We did not have time to visit this part of the river, and simply noted them from a distance. The alluvial bottoms are very limited in extent.

Gunnison River.—The valleys of the Gunnison, its North Fork, and their tributaries are terraced in a beautiful manner. All the drift is probably of local origin. The terraces are cut mainly in the soft shales of Upper Cretaceous age, which have been treated of in the previous chapter. There are scattered patches of alluvial material. These areas have already been described, and description here would be a repetition.

Erosion.

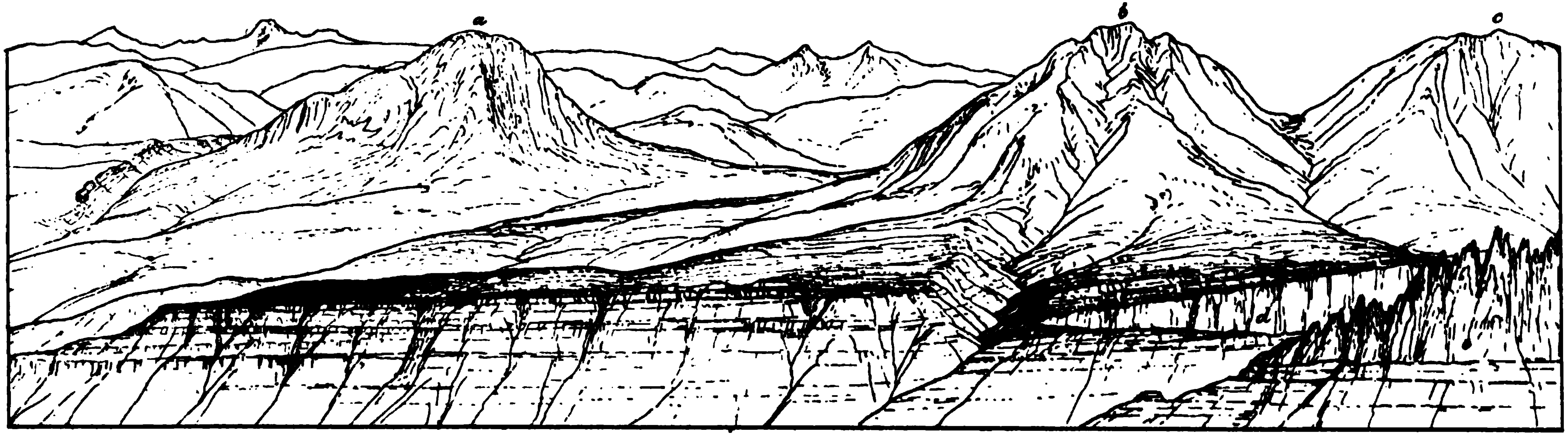
The valleys of nearly all the streams in the district are simply erosive, although a number were perhaps determined in their present course by breaks in the strata, the result of folding. It would be impossible even to estimate the enormous amount of erosion to which the strata west of the continental divide, in our district, have been subjected since the beginning of Tertiary time. The amount of erosion during the Tertiary time was enormous. It was sufficient to form beds thousands of feet in thick-

ness. In section No. 19 of Tertiary strata we have seen that there are over 7,000 feet of beds. A large part of their ingredients was doubtless derived from the Sawatch range. Over the mass of the Elk Mountains, the Cretaceous, with underlying strata, have been removed, to a great extent, leaving only on the edges remnants of the Cretaceous. On the western flank of the Sawatch we see no Cretaceous. This will give us some idea of the enormous denudation that has been effected. A large portion of this denudation was doubtless the result of glacial action.

The erosion going on at the present time is by no means inconsiderable in amount. The high water during the spring months carries down a vast quantity of material. During the rainy seasons the rain comes in frequent showers, which, although of short duration, are very violent, and wash down immense quantities of material, cutting deep gullies into the bluffs. The softness of the beds on Eagle River, on Grand River below Roaring Fork, and on the North Fork of the Gunnison, renders them very susceptible to aqueous influences. In the mountains, the alternate freezing and thawing of the snow-banks, in the spring and summer, has considerable influence on the erosion. The alteration in the level of the streams is often very perceptible.

Another agent of erosion has been pointed out by G. K. Gilbert, in a paper read before the American Association for the Advancement of Science, in 1874, viz, that caused by the action of sand carried down the streams on the rocks through which they flow. The erosion effected in this way is very considerable, especially where the beds of the streams are in solid rock. Our district was so broken by hills that the action of wind in eroding the strata is not so noticeable as in more level countries.

Plate XI.



Bluff on Coal Creek
a. Marcellina. d. Dyke.

CHAPTER VIII.

ERUPTIVE ROCKS—TRACHYTES—TRACHORHEITES—BASALT.

I separate the volcanic areas of the district into three divisions, according to the character of the rocks covering them: first, the porphyritic trachyte forming the group of mountains marking the western or southwestern termination of the Elk Mountains in the southeastern portion of the district; second, the trachytic areas (mostly rhyolitic underlaid by breccia) which form a large part of the southern portion; third, the basaltic areas that prevail in the northern part.

The rocks of the second division correspond to the "Trachorheites" of Dr. Endlich, and in fact are the northern and western extension of those rocks described by him in the report for 1873 under section *c*.*

With the exception of the first division, the volcanic rocks form the tops of plateaus which have been much modified by erosion. These plateaus are generally covered with a luxuriant growth of grass and scattered groves of cottonwoods.

The volcanic rocks of the first division form beautiful isolated mountain masses, surrounded with sandstones of Cretaceous age.

The rocks of the third division are probably of most recent age, although it is difficult to say definitely that they are more modern than the rhyolitic rocks in the southern part of the district. The latter prevail largely in the district assigned to Dr. Endlich, and he probably secured more evidence as to their age than I was able to.

PORPHYRITIC TRACHYTES.

Although the rocks that I shall describe under this head differ considerably from each other, they have the same general constitution. They contain the same minerals, and are generally of light-gray colors, with crystals of feldspar porphyritically imbedded in the mass with hornblende and occasionally mica. They resemble the rocks found throughout the Elk Mountains in 1873, especially those found at Gothic Mountain and the various dikes found penetrating the sedimentary formations. Some of the more compact varieties have a granitic appearance, reminding one of the rocks forming the central masses in the main mass of the Elk Mountains.

The physical features of the country in which these mountains are have been fully described in previous portions of the report, and I therefore simply refer to them here.

The isolated character of the peaks is well shown in Plate XI. *a*, *b*, and *c* represent some of the trachytic peaks, which stand like huge monuments in the midst of the Cretaceous sandstones which are seen outcropping in the bluff in the foreground of the picture. At *d* and *e* is shown a dike of trachyte, which once formed one continuous mass.

* Report U. S. Geol. Survey 1873, page 343.

It is scarcely to be doubted that all these mountains are eruptive in their origin. The evidence pointing to this fact will be referred to as we proceed. The sandstones surrounding them seem to have been but little disturbed by the thrusting-up of these masses. It is difficult to get at the line of junction between the trachyte and the sandstone, as the slopes on the mountains are very steep and the bases are entirely concealed by the mass of *débris* washed down. It is probable, however, that the ends of the sandstones would be found slightly tipped up. On Anthracite Creek, on the north edge of Mount Marcellina, the sandstones are tipped up and penetrated with dikes, as shown in Plate XII. On the northern side of the area, marked A, on the map C, the sandstones are tipped up, dipping to the northward at an angle of 20° to 25°. It is a curious fact that these western terminations of the Elk Mountains should all be trachytic, while in the main mass of the Elk Mountains the granitic character should predominate. In the dikes, however, the rock was always trachyte. Proceeding westward, also, trachyte became more abundant. In the region I have under consideration at present the varieties of rock that most resembled granite were found in the eastern portion. The dikes always gave the best typical specimens of trachyte. Some of the specimens are rhyolitic. I only refer to these facts to show the analogy between the trachytes and the eruptive granite of the Elk Mountains. Until these rocks are all subjected to a close microscopic and chemical analysis and the region in which they are found examined in detail, all opinions must, to a certain extent, be conjectural. The Elk Mountain region presents one of the most interesting fields of study, and one which will yield more material for the study of eruptive granites than any other on our continent.

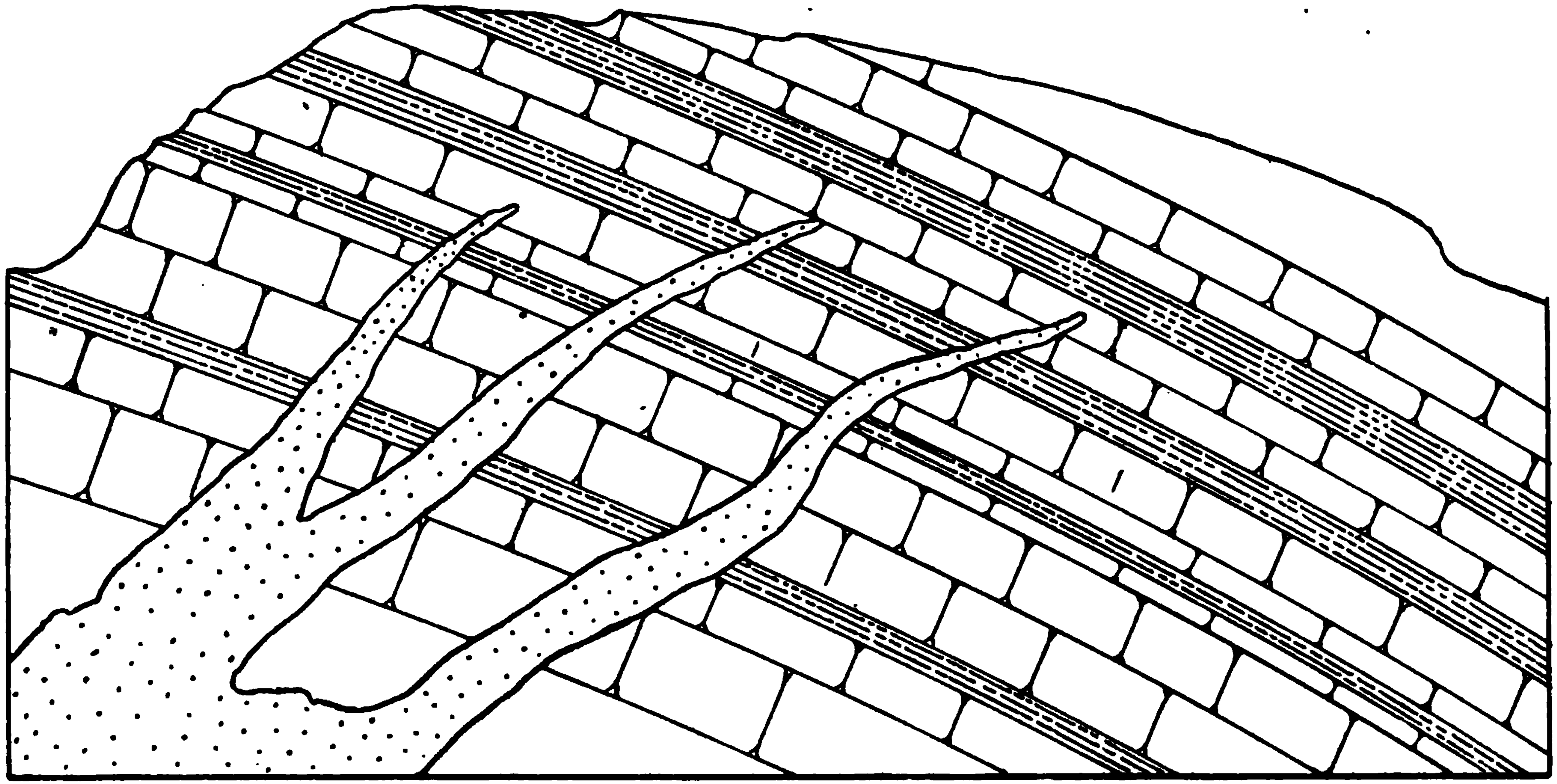
I will take up these areas in the order in which they are lettered on the accompanying map (C), which gives a much better idea of the outline of each than could be given in words.

The eastern groups are those which, in Lieutenant Ruffner's report,* are called the Philosophers' Monuments.

A.—In ascending Ohio Creek, the hill on which station 30 is located forms a prominent feature of the landscape. It is sugar-loaf in form, and rises over three thousand feet above the level of the valley of Ohio Creek. Its slopes are steep, and at the base is an accumulation of rocks that have been washed down its sides. The rock is a porphyritic trachyte. There is a rather compact matrix, inclosing white crystals of feldspar, free quartz, and small crystals of black mica. The mass north of station 30 is broad-topped, and composed of the same kind of rock. East of station 30 is another mass, not shown on the map. It was not visited, but is probably similar to that of station 30. The western part of the area, marked A′ on the map, is a ridge, with numerous sharp points. The pass from Ohio Creek to the head of Anthracite Creek, is at the eastern end of this ridge, at the point *b* on the map. This pass is 1,800 feet below the summits of the ridge. I am in doubt whether or not this area is separated from the mass of station 30, marked A. I have provisionally connected them on the map. At the western end I am also doubtful, as I have never been on the saddle that separates it from the area E. This saddle seems to be comparatively low, as seen from the surrounding country, and I think it probable that the Cretaceous sandstones connect across it. The dotted lines indicate the doubtful part. On the north side there are Cretaceous sandstones dipping to the north,

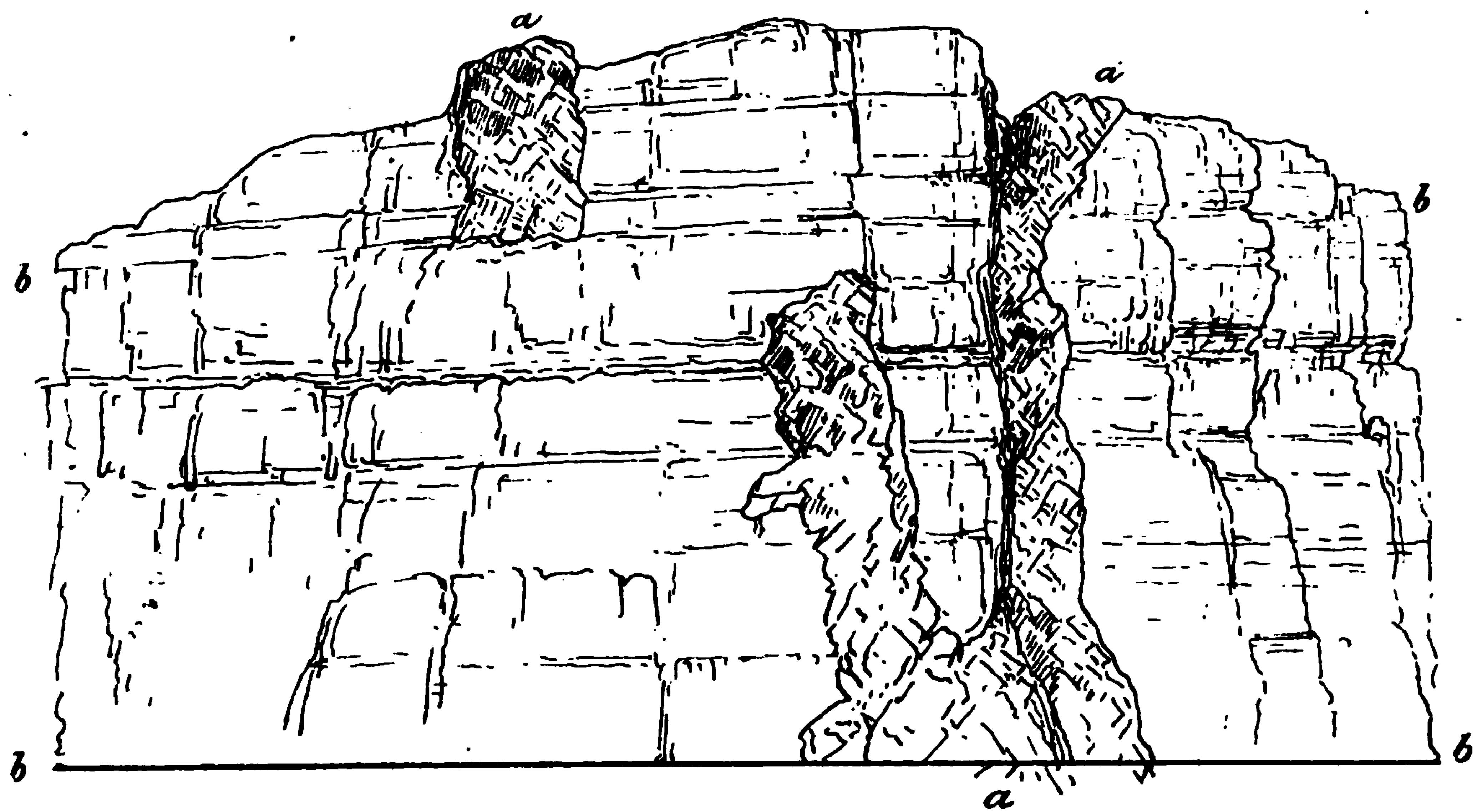
* Report of a Reconnaissance in the Ute Country, page 40.

Plate XII.



Dykes in Sandstone on Anthracite Creek near Mt. Marcellina.

Plate XIII.



Dykes in Bluff at the head of "Oh be joyful" Creek.

at an angle of 20° to 25°. It is in these sandstones that the anthracite coal occurs, at the point marked *m* on the map. On the southern side there are also sandstones, but, as far as I observed, they are horizontal. Towards the west end of the ridge, resting on these sandstones, is a mass of breccia, which seems to abut against the trachyte. The line on the map indicates this breccia. A specimen of trachyte from the eastern end of the ridge has a rhyolitic appearance. It is light-gray in color and contains a great deal of free quartz. The matrix is rather coarse, and contains large crystals of glassy feldspar and small hexagonal crystals of a brownish-black mica and a few small needles of hornblende.

Above the coal-bed mentioned as occcurring on the north side of this area there is a layer of trachyte in the shales and sandstones. It resembles the rock just described in appearance and construction, being perhaps a little rougher and having the hornblende in greater quantity. The crystals of feldspar are not so large. The free quartz has the appearance of pebbles, the edges being rounded, probably the result of heat.

B.—Station 32 is the mountain named Mount Richard Owen by Lieutenant Ruffner.* He says, "Mount Richard Owen has two peaks, the northern of which is the higher, of dusty-red rock, probably ferruginous quartz, or perhaps trachyte." The mass of which station 32 is only a portion, is composed of Cretaceous shales and sandstones intersected and metamorphosed by numerous dikes, of which the principal ones are shown on the map. To accurately define all the dikes in this region will require a very close and detailed survey. Station 32 seems to be a center for them. In the ridge southeast of the station there is a layer of trachyte between layers of sandstone. The section in which this occurs was given in a preceding chapter. This rock is rather more compact and finer textured than the trachytes I have hitherto described. The porphyritic character is not so decided. It is of a light greenish color, and seems to be slightly arenaceous, as though it had taken from the surrounding rocks a portion of its sandy material. It is perfectly conformable with the sedimentary rocks, and, under other circumstances, might be taken for a contemporaneous flow. It presents a square, massive edge on the bluff, as shown at C in Plate X. The dike, marked *a b* on the map, is also shown on this ridge cutting across it almost at right angles to its strike. It is about 300 feet in width on the ridge and inclines slightly to the northeast. At right angles to it is a narrow seam of quartz, inclining west at an angle of 85°. This seam could be distinctly traced for several miles on the ridge. I was unable to trace the eastern extension of this dike to its extreme limit. The rock of this dike is a greenish-gray trachyte, rough in texture and containing a large number of feldspathic crystals.

Crossing the same ridge a little farther north is another dike, the one marked *e f* on the map. Plate XIII shows the appearance of this dike as seen on the face of the bluff, *a a a* representing different portions of it intersecting the sandstones *b b b b*. The rock in this dike differs greatly from the others. It has a very compact, fine-textured, dark-greenish matrix, in which are a few small crystals of feldspar. They are more conspicuous on the weathered surfaces. Besides the feldspar there are particles of free quartz. The specific gravity of this rock is greater than that of those from the other dikes. The dike *c d* of the map forms a very prominent ridge leading down from station 32

* Report of Reconnaissance in the Ute Country, page 40.

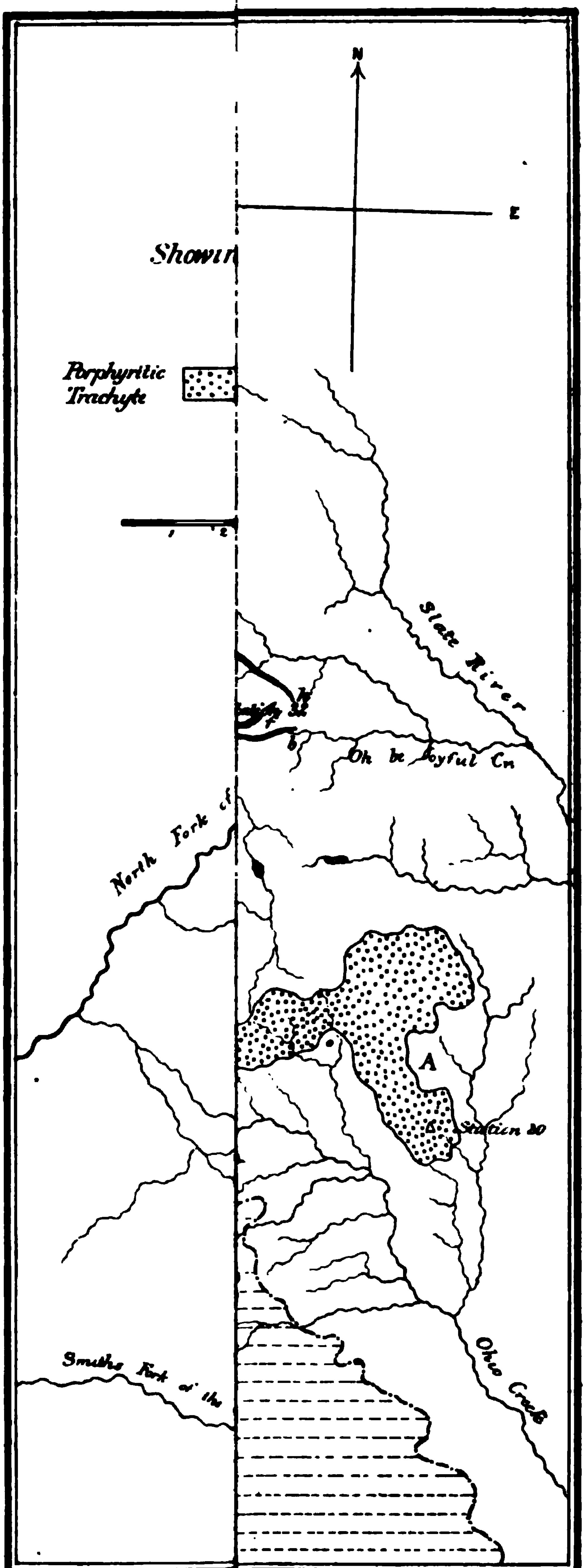
to Anthracite Creek. Its hardness has preserved it while the surrounding rocks have been removed. Its summit presents a ragged edge, spire-like processes rising from it. The rock is very much like that of Mount Marcellina, and that of areas described under A and A′. The dike *g h* has a course almost at right angles to the one described. I was unable to visit it, but am inclined to think it a continuation of the one marked *a b*. Other dikes in this region are shown, but were not visited. They by no means represent all the dikes that are to be found, but merely the principal ones. The mass of mountains north and east of station 32 contains many more that we were unable to define.

C.—The center of this area is Mount Marcellina, a steep mountain, the general shape of which is sugar-loaf. It is shown at *a* in Plate XI. This is probably the mountain to which Lieutenant Ruffner gave the name of Mount Huxley,* as it answers the description. On the map accompanying his report, however, Mount Huxley is marked as being on the opposite side of the creek. It being, therefore, somewhat doubtful, we have used the name Marcellina applied to it by prospectors that we met in this region. The slopes are very steep, and the base surrounded by a mass of *débris*. The sides are weathered into conical, spire-like forms which stand out in bold relief, especially on the western and southern sides. It is 11,324 feet above sea-level, and about 3,000 feet above the top of the sandstones that form the surface between it and the area marked D on the map. It is over 4,500 feet above the level of Anthracite Creek, on the northwest side. The trachyte of Marcellina is very fine-grained, resembling closely the eruptive granites of the Elk Mountains. On the northwest side of the mountain the Cretaceous layers are tipped up, dipping to the northwest 15° to 20°. This is the only point at which any disturbance of the strata around the mountain could be seen. Here also they are penetrated by dikes of the same material of which the main mass is composed. It was perhaps more porphyritic. Plate XII represents three of these dikes on the southwest side of the creek. On the opposite side there is a much larger mass of this rock resting on the sandstones. I think it probable that the trachyte extends from Marcellina to the north side of Anthracite Creek. Whether it extends to the westward connecting with C I am not so certain. I have indicated the intermediate portion by dotted lines. We did not have time to follow Anthracite Creek throughout its entire length.

D.—This area is the second in size, and comprehends 25 or 30 square miles. It consists of a number of sharp peaks connected by sharp ridges bounding amphitheaters in which rise streams tributary to Rock Creek on the north and east, and on the south and west flowing to the North Fork of the Gunnison. The western side of this mass is very steep, the angle of the slope being about 50°. The summits are from 2,000 to 2,500 feet above the general level surrounding the mass. This western side is not broken up by gullies. It preserves a uniform wall-like surface for nearly three miles. The amphitheaters that we have referred to are found on the southern and eastern sides, the majority of the drainage being into Rock Creek. The eastern side is therefore most irregular and shows most markedly the effects of erosion. Rock Creek, opposite station 33, before it bends to the northward is 5,000 feet below the summits of the peaks. The rock of station 33 is similar to that of Marcellina, the only difference being that the component parts in the former are much coarser.

At D′ and D″ there are two areas whose limits I am unable to define

* Report of Reconnaissance in Ute Country, p. 41.



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with exactness. Between D and D′ there are Cretaceous rocks. Treasury Mountain forms the center of the second area. The Cretaceous rocks in this region have been lifted up and so broken, that the lines of outcrop cannot be distinctly seen from a distance. For more detailed information in regard to the rocks here, the reader is referred to Mr. Holmes's report.

E.—Only the western end of this area was visited. A view of it is seen in Plate XI, at *b* and *c*. The area E′ is seen at *d*, and E″ at *e*. The two latter are evidently parts of the same dike; a branch of the creek separates them. At E″ the trachytic simply caps the ridge, forming a small isolated patch. This dike was once evidently connected with the trachyte east of station 34 (the area F). The dike *d* in the illustration is evidently connected with the mass *b*. The rock from the dike differs slightly from that already described, the mica not being so predominant. It also contains more hornblende. It is of a very light gray color, very compact and fine-grained.

F.—This is the most irregular, and by far the largest of the trachytic areas. It includes 50 or 60 square miles. Our most eastern station in this area was station 34. In ascending the ridge towards the station, there was noticed an indistinct lamination in the trachyte; some of the beds have calcite. There seems to be an alternation of hard and soft layers, rocks from the latter weathering with rounded edges. The trachyte is more vesicular than any yet described; the crystals of feldspar are clearer and have more of a glassy appearance. The rock is generally of a dull-gray color. The weathering of the mass, of which station 34 is the center, is very different from that of Marcellina, and of the ridge forming the area E. The mountains here are more massive, and the creeks draining them head in amphitheaters, separated from each other by long sloping spurs which have very steep ends. To the northeast they descend to the top of a mesa of sandstones. This mesa on the opposite side of the creek is shown in the forgeround of the picture in Plate XI.

On the east the descent to the level of the creek is very steep. There are remnants of Cretaceous shales, with coal still resting against the ends of the spurs.

The arm that extends to the southward, west of station 36, rests against a mass of breccia, which will be described with the next division of the eruptive rocks. The northern edge of this breccia is indicated by a dotted line. In this southern area there are four or five prominent peaks, none of which we visited.

Between the southern arm and the southern prolongation of the western arm around station 37 is an irregular area of Cretaceous, which has been fully described in a previous chapter. The eruption of the trachyte seems to have caught these rocks and tipped them up in all directions. They seem also to have been much metamorphosed.

In the western arm, stations 38 and 39, are the principal peaks. In the arm connecting this part of the area with that to the eastward there are several peaks equally high. Station 38, as viewed from the west, is a sharp, conical peak, rising very steeply for 1,800 or 2,000 feet, and from that point sloping gradually towards Smith's Fork. Fig. 1, Plate VII, gives a section from the station westward. Station 39 is also sharp, and also shows very prominently from the north. The rock of both mountains is the same. Numerous white crystals of feldspar and a few crystals of hornblende are imbedded in a gray matrix. The country around both stations is comparatively low and filled with soft shales of the Upper Cretaceous layers which form low butte-like hills. Seen from

the summits of the peaks they seem merely irregularities in the surface. Station 38 is 10,634 feet above sea-level. It is the last peak of the Elk Mountains to the west, and from its summit one can see the dim outline of the Sierra la Sal Mountains, 100 miles farther west. Station 39 is higher, having an elevation of 11,337.

G.—This area consists of a double-topped hill of trachyte, rising about 1,000 feet above the cretaceous rocks that surround it. It is well wooded to its summit, which is broad. The slopes are not very steep. The North Fork of Smith's Fork curves around its northern end. The trachyte composing it presents no features different from those of the rocks already described.

H.—Opposite this double-topped mountain, which we called Saddle Mountain while in the field, is a trachyte point rising between 300 and 400 feet above the level of the creek, standing like a finger in the midst of the Cretaceous rocks.

K.—This is the last trachytic area to the westward. The hill in which it is shown is low and rounded, being only 1,800 feet above the level of Smith's Fork. The face toward Smith's Fork shows the trachyte best. It is of a light-gray color and porphyritic. It does not differ materially from that of station 38. East and north there are Cretaceous shales, and on a low hill back of it there is a dike of similar rock lying at the base. This is on the layer marked No. 1, in section 16, given in chapter VI. The eruptive force seems to have been dying out to the westward, and the last evidence we have of its action is in the cañon of the south branch of Smith's Fork, where the bending of the No. 1 Cretaceous caused a break, which gave origin to the cañon.

In the consideration of the areas just described it will have been noticed that there were numerous points at which the intrusive character of the trachyte was not to be doubted, as near station 34 and near Mount Marcellina. These rocks are the same that are seen in the large areas, and if intrusive in one place are probably so in the others. The elevation of these mountains is Post-Cretaceous, and probably of more recent date than the rhyolitic flow from the south, for the northern edge adjoining this area is tipped up, where the trachyte has not been removed, and, where it has, the underlying breccia forms the summits of the mountains, its level being much higher there than along the Gunnison River.

TRACHORHEITES.

Under this head I will describe the rocks of the mesa-like country extending along the Gunnison, on both sides, as far as the Grand Cañon. The accompanying map (map D) will give the extent and distribution of the rocks comprehended. Their character and order of superposition will be given in detail as I proceed. The source of the flow is to the southward in Dr. Endlich's district, where there is a much greater thickness of the rocks, those exposed on the Gunnison being merely the overlying edges of the upper layers, those underneath not having spread so far to the north. East of Ohio Creek there are two mesa-like summits crowning the broad ridge between Ohio Creek and East River. These mesas are trachytic, and seem to rest immediately upon beds of Cretaceous age. I do not think there is any breccia beneath, as there is farther west. The general level of the mesas would seem to indicate that they are remnants of the layer that forms the mesas north of the Gunnison. The hills west of Ohio Creek are composed mainly of breccia, the trachytic capping having been removed. The soft beds have been eroded in the most fantastic fashion. The breccia is

Plate XIV.

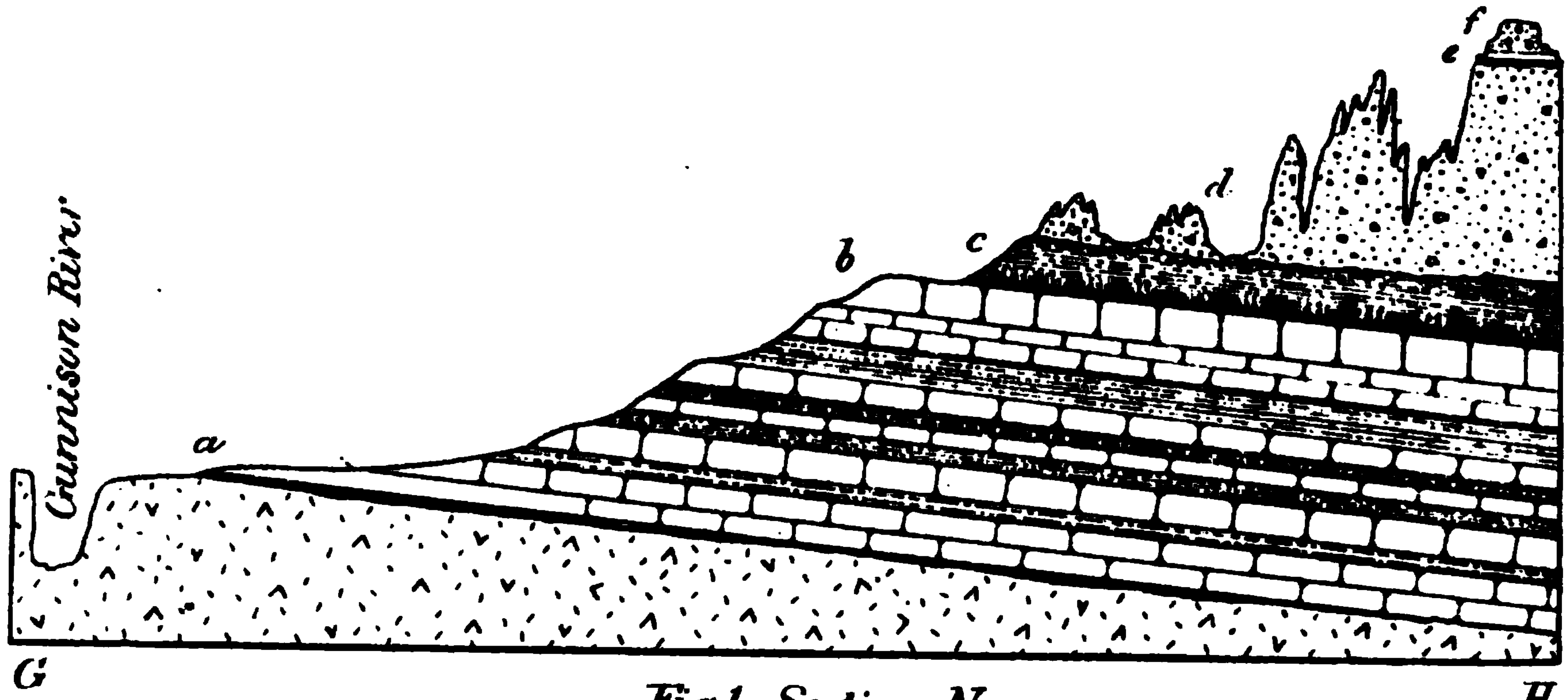


Fig 1. Section N.

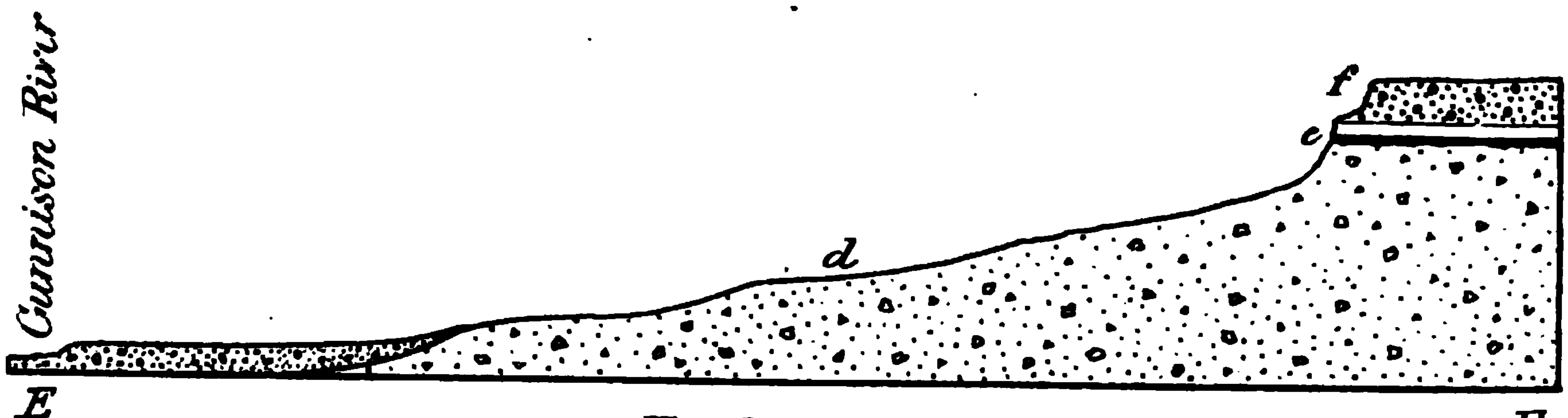


Fig. 2 Section O.

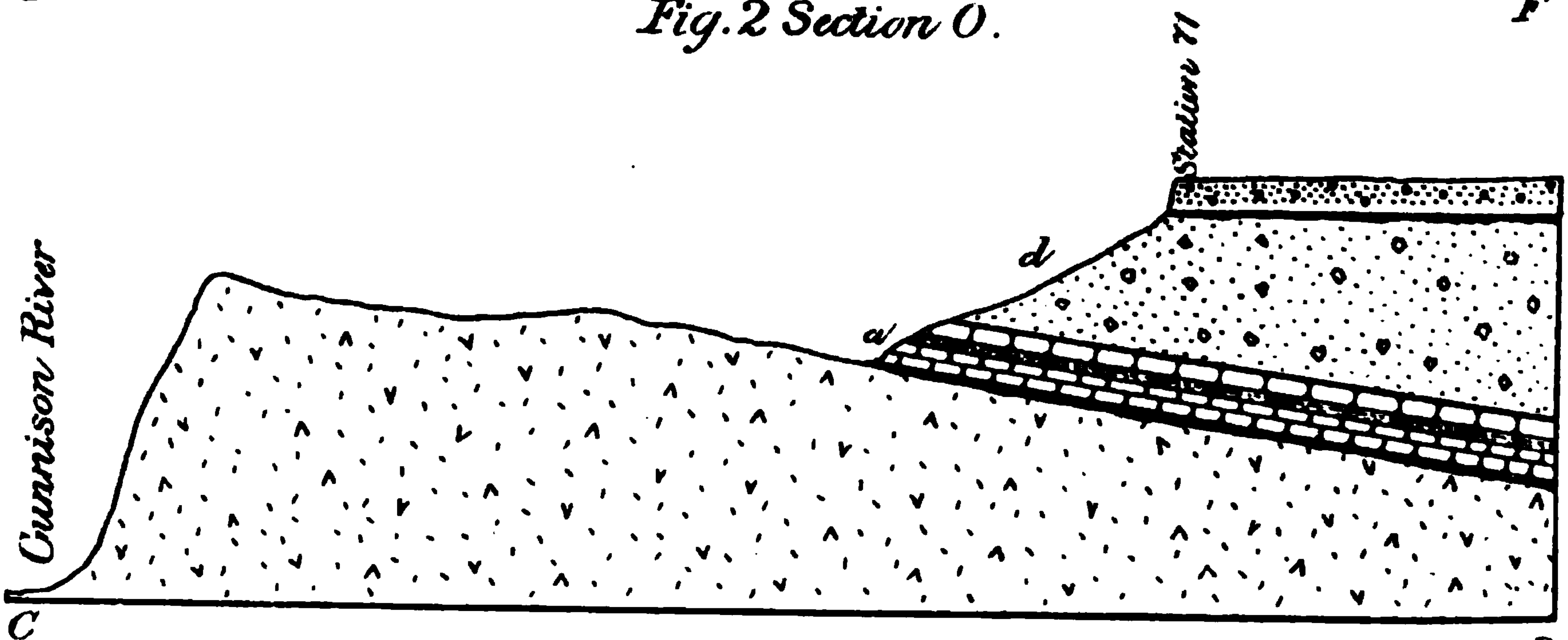


Fig 3. Section P.

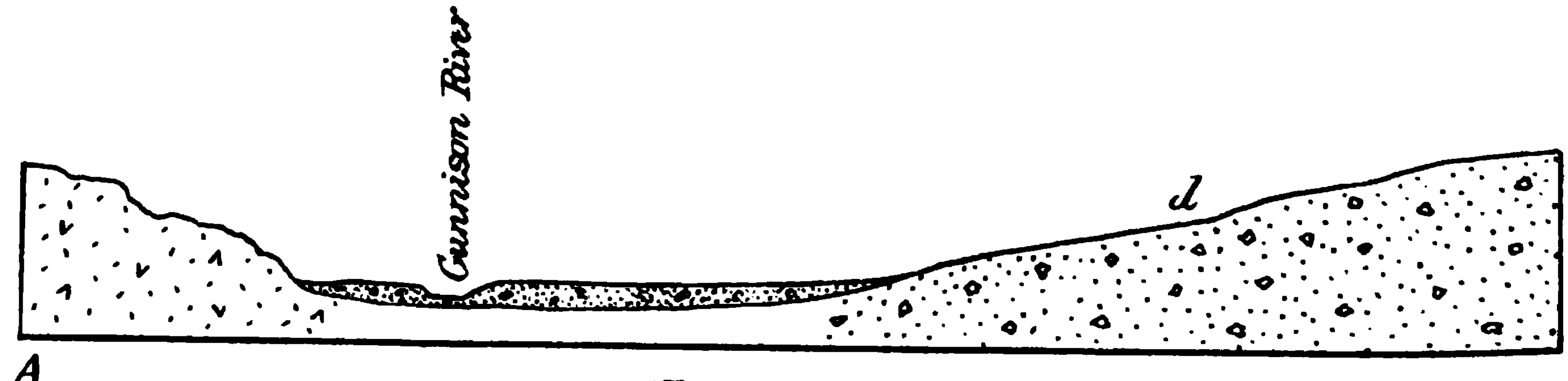


Fig 4. Section R

stratified, and there are huge castle-like forms, abrupt walls, and spires and towers. Station 31 is situated in the midst of a mass of hills of this material, their summits being generally broad and rounded. The thickness of the breccia at station 31 is about 3,000 feet. These hills slope toward the Gunnison in long, gentle spurs. The breccia north of station 31 rests against the edge of the hills of porphyritic trachyte, already described. It rests for the most part on Cretaceous sandstones. The line of junction is seen on the west branch of Ohio Creek and on the Gunnison at various points. It is probable that in the center there may be shales between the sandstones and the breccia, as at station 73, on the Gunnison. The valley of the Gunnison, on the north side from Ohio Creek as far as station 71, has been subjected to considerable erosion, and the breccia forms the basis of the hills. It probably rests partly on the schists, with an occasional patch of sandstone between, as indicated by an outcrop in the bluff opposite the mouth of Cochetopa Creek. Fig. 4, Plate XIV, represents a section across the Gunnison, in the meadow below the mouth of the creek. Fig. 3, on the same plate, is a section through station 71. Here the sandstones appear and the breccia is capped with a white rhyolitic rock, which is probably underlaid by obsidian and tuffa, as we see farther down the river. Under station 71 the line of junction is concealed. West of the station, below the cañon which the river cuts in the schists, there is a steep dip of the sandstones to the west or southwest, which is the reason they do not outcrop in the section in Fig. 2, which is made below the cañon. Bordering the valley in which this section is made, on the north side, are a number of buttes capped with obsidian and trachyte. Back of them the mesas extend toward the hills to the northward. These mesas are exposed on both sides of the Gunnison. At station 73 I made the following section of the volcanic layer:

Section No. 20—Gunnison River, near station 73.

	Base.	Thickness. Feet.
d	1. Breccia	400
e	2. Light pinkish-white tufa 3. Gray laminated trachyte 4. Hard obsidian porphyry 5. Soft spherulitic and porphyritic obsidian	40
f	6. Purple vesicular rhyolite	50
f	7. Bluish-gray rhyolite	30
	Top.	
	Total	520

This section goes as far as the top of the bluff, but as we go back there is a greater thickness, and probably a repetition of the upper portion of the section, that is from the obsidian upward. The letters in the section above correspond to the letters in Fig. 1, Plate XIV. As the rocks of this section are typical of the rocks in these mesas, I will describe them more in detail. The breccia I will pass by for the present. The tufa, which rests immediately upon it, is almost white in color, and appears to be made up mainly of feldspathic material, with particles of quartz and mica interspersed. It is soft and very fine in texture, having a sandy feel when crushed in the fingers. Above station 73 this tuff is about five feet thick. Layer No. 3 is a dull, purplish-gray rock, in which there are numerous particles of quartz and obsidian, with crystals of sanidine porphyritically imbedded. There are also a few crystals of black mica. Under the glass this rock has a vitreous appearance. It is probably rhyolitic. It is from two to four feet thick. Layer No. 4 is very hard, and breaks into square blocks, with very smooth,

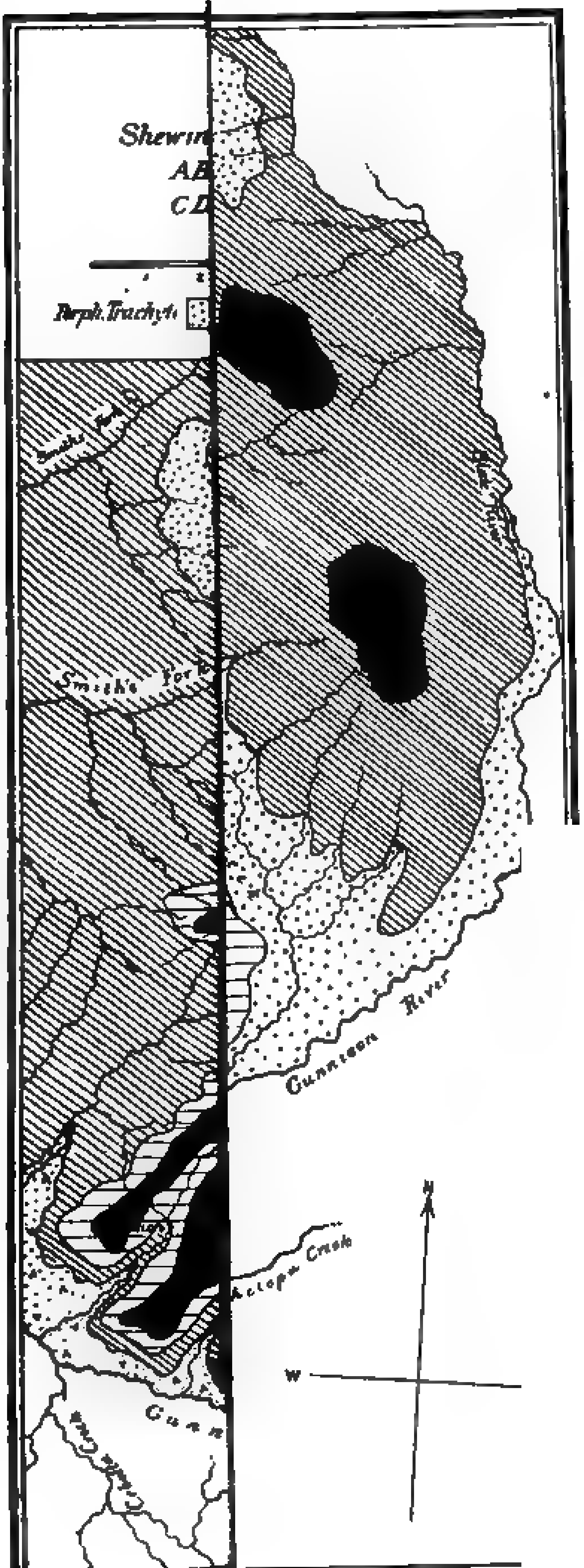
regular faces. There are numerous crystals of sanidine in the obsidian. As we ascend, the bed becomes softer, and besides sanidine contains small spherulitic masses, which are generally about the size of a pin-head. In some places, however, they are an inch or two in diameter, and when broken open the cavities in them are found coated with *Hyalite.* This spherulitic obsidian is exactly like that found by us in the Yellowstone National Park,* and a description of one would answer for the other. Layer No. 6, in the section given above, is a compact jaspery-looking rock, slabs of which ring under blows of the hammer. In the crypto-crystalline paste are crystals of sanidine, bronze mica, free quartz in abundance, and occasionally a pebble of what has the appearance of having been tufa inclosed and metamorphosed. This rhyolite is vesicular, the cavities being lined with blue chalcedony. These cavities are most abundant in the lower part. The description of this rock answers for the layer wherever it is shown along the Gunnison, the only difference being in the color, which at station 73 is a purplish-brown. At station 77 it is more of a gray. The geodes of chalcedony are very abundant in the latter place. Layer No. 7 breaks into slab-like masses which weather white. They ring under the hammer like the layer below. Just above it are indications of a tufa, resembling that above the breccia. It seems to be of a reddish color. Along the second creek west of station 73 the trachytic capping has been removed, and the breccia forms the basis for a considerable distance up the creek, the mesa-form disappearing with the removal of the trachyte. The creek west of stations 77 and 78 forms the present western boundary of this trachytic area. At the head of the creek, as seen from station 79, the trachyte is tipped up, dipping toward the south or southeast at an angle of 10° to 15°. This is also the general direction of the slope of the mesas. Station 79 was located on a point capped with a remnant of the lower part of the trachyte, below which is the breccia. It is impossible to tell at present how far west this flow originally extended.

The breccia which we have referred to so often in the present chapter is generally of a dark-gray color in the matrix. The included masses are of all sizes, and generally angular. The greatest variety is seen near station 31. I have already spoken of the stratified character at this point, which seems to indicate its deposition in water.

The upper layers seem to be lighter-colored and to have the included smaller masses. Farther down there is a dark band, below which the included rocks are in large masses. These layers are variegated, red, green, yellow, and gray. Between the layers are bands resembling a hard sandstone and also tufaceous layers. The included masses are, I think, all trachytic. The tufaceous layers are pink and ash colored, and contain conspicuously black mica and minute crystals of hornblende.

Preceding the deposition of this breccia, there was considerable erosion, as is indicated by comparing the underlying rocks at station 73 with those under station 79. In the former place there are only a few feet of shales between the Dakota group and the bottom of the breccia, while at station 79 there must be at least 1,000 feet, and there is probably more farther back. On the Gunnison, also, as seen by the sections in Plate XIV, there is abundant evidence of such erosion. The drainage had probably the same general direction as at present. It is also probable that there was an interval between the deposition of the breccia and the flow of the rhyolitic rocks, during which there may have been some erosion of the breccia. It varies greatly in thickness. At station 31 it is 3,000 feet, while on the Gunnison, at station 73, it is only 400 feet.

* Report U. S. Geol. Survey, 1872, page 131.



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I have already stated that the origin of this trachyte and breccia is in Dr. Endlich's district, south of the Gunnison. Since it was poured out, the mass of mountains described under the head of Porphyritic Trachytes have been thrown up, which fact accounts for the abrupt bending of the trachyte northeast of station 79, and the general slope toward the Gunnison. The subsequent erosion has been sufficient to remove the trachyte around station 31, and on the ridges running southward from this mass of mountains. The amount of the denudation on the Gunnison is measured by the distance between the top of the mesas and the level of the River.

BASALTIC AREAS.

The basaltic rocks of the district all closely resemble each other. They are generally dark-colored, gray to black, and are fine-textured. They contain olivine, sometimes free quartz, the latter not abundantly, and on being pulverized magnetic iron can be extracted from them. The latter always caused a great deflection in the needle at all stations made on these areas. Vesicular varieties occur in many places. The different varieties, however, will be described as we proceed. The shortness of the time at our disposal in the preparation of this report precludes the possibility of giving definite analyses of the rocks.

As already stated, the basaltic rocks are confined to the northern part of the district, where they generally form the capping of plateaus or mesas, showing that they are lava-flows. Their source was probably to the northward, as, with the exception of one locality, I could find no evidence of their having originated within the limits of our region.

As the general features of the country have been already given in considerable detail I will confine myself mainly to the description of the rocks and their mode of occurrence.

Eagle River.—On the summit of the ridge southwest of the Eagle River, opposite the second cañon, there is an isolated area of volcanic rock which I call basalt, although I could discover no olivine. Its appearance, however, closely resembles that of the rocks in the same region that are undoubtedly basaltic. It is dark bluish-gray, rather compact, with a slight tendency in places to lamination. There are a few points of free quartz and numerous yellow spots of some decomposing mineral, which may be olivine. The area occupied by this rock is limited, comprehending only about nine square miles. It is shown on map A. A section across it is shown in Fig. 1, Plate I (*f* to *g*). It will be seen that it rests on the upturned edges of the Red Beds, and in places touches the Jurrassic or Cretaceous layers. The section in the figure is partly ideal, but I think it presents the true relations of the rocks. It seems that there must have been a fissure through which the material was pushed, and afterward spreading out, it covered the edges of the strata tipped up by the same force that caused the flow. If it is simply a flow that has spread over the upturned edges of the strata it must have come from the north. The hills north of Eagle River shown at *c c*, in Plate II, are capped with volcanic rock. It is not probable, however, that this rock is the same flow, although it may be of nearly the same age. We cannot be exact as to the age, although it is probably comparatively modern. All we can say positively is that it is Post Cretaceous at this point. I think this flow and the one near the mouth of Eagle River were contemporaneous. The latter, as I shall show, is of recent date. It is near the mouth of the river on the north side, and, although outside of the limits of our district, I wish to refer to it. A more detailed description will be given by Mr. Marvine. The flow had its source in the hills on the north side. It came down the ravines and

spread out in the valley, covering a space of three or four miles. It forms a bluff edge 10 to 20 feet above the level of the river. A specimen of the rock that I obtained is a black vesicular basalt containing free quartz and olivine. On pulverizing it I obtained a dark, almost black, powder from which magnetite could be separated.

This rock is of comparatively recent date, which is evident from the following reasons:

First. The flow has taken place since the carving out of the valley. It occupies the bottom of the valley, which is nearly two thousand feet in depth, bordering the river like the slag poured out from a furnace. The river seems to be the limit of the flow, none of the rock being found on the south side. It was probably pushed by it to the lower side of the canon-like valley.

Second. The subsequent erosion has been very slight. The basalt is exposed in a bluff-like wall which reaches to the level of the water, nothing being exposed beneath it.

Third. The basaltic rock is destitute of vegetation and comparatively free from any soil. It has the appearance of having just been poured out. The period during which it was poured out is probably to be measured by hundreds of years, and perhaps less, rather than by longer periods.

Grand River.—Below the mouth of Eagle River on the south side of Grand River there is an area of volcanic rock that has been subjected to considerable erosion. This area was probably once continuous with that west of Roaring Fork. Between *a* creek, Grand River and Roaring Fork it rests mainly on beds of Triassic age, forming a plateau-like surface. Near the mouth of Frying-Pan Creek is a mesa capped with basalt which is probably a portion of the same flow. This latter, however, rests on beds of Cretaceous age, as does the volcanic rock west of the Hog-backs on Roaring Fork. They are all probably remnants of the same flow. The amount of erosion previous to the spreading out of this material was very great. The Cretaceous rocks near the Grand, between Roaring Fork and *a* creek, seem to have been entirely removed. The subsequent erosion also has been of great extent. The present valleys and cañons have probably been outlined since, and the amount of denudation is to be measured by their depth below the level of the volcanic rock.

The capping of the hills west of Roaring Fork is very irregular. There remain only the remnants of what was once a connected mass. Station 16 was located on the western edge of one of the patches of basalt.

In almost all of the valleys drained by the southern branches of the Grand, between Roaring Fork and the plateau of station No. 48, there are great numbers of volcanic bowlders, derived from the hills that are capped irregularly with basalt. The hills themselves are so covered with *débris* that it is difficult to define the boundaries of the basalt. The plateau on which station 48 is located is also capped irregularly with basalt. Since the flow it has been subjected to a great deal of erosion, and now the basalt is found only in isolated masses, like that on which we made station 48. The latter is a mammallary process rising 248 feet above the general level, and about 200 feet in diameter.

The following is the section of this curious horn-like point, which can be seen from a great distance in every direction:

1. Dark-gray basalt, containing a large quantity of olivine, also free quartz sparingly. It is a very hard and compact rock.

2. Purplish basalt. This layer is slightly vesicular. It contains the same minerals that are seen in No. 1.

3. Vesicular basalt. Mostly red in color on weathered surfaces. Some of the pieces found at the base are black, and have cavities lined with carbonate of lime.

4. Tufaceous layer, of which only the upper portion could be seen. The color is white, and in some places the layer has masses of basalt.

In layer No. 1 I found the following minerals, besides those mentioned above: Hyalite and quartz in segregations and pyrites coating the weathered surface in a few instances. All these basaltic rocks have magnetite. The local attraction on the station was considerable.

The cone on which station 48 was located is situated in an isolated patch of basalt of the same character (see map 3). There are several other areas from which pointed and coffin-like masses rise, none, however, reaching the altitude of station 48. The basalt, as has been mentioned in a previous chapter, rests on dark-gray shales which weather to a chalky whiteness. This is beautifully shown on the north side of the Grand. It was impossible to tell from the station how extensive the area covered by the basalt is to the north. On this plateau the area does not exceed eighteen or twenty miles. To the westward it reaches its limits at least five miles east of station 50. West of the basaltic line the plateau becomes broken; the capping having been removed, the soft beds beneath yielded readily to the eroding influences, and, therefore, instead of a plateau there is a sharp ridge, gradually decreasing in elevation to the westward. The course of the range, for it forms a very well-defined range, is generally west. It is very irregular, however, and the streams on either side cut profoundly into the strata.

Station 48 has an elevation of 11,063 feet above sea-level. Two and a half miles west the top of the basalt is 150 lower, and two miles farther, that is, four and a half miles west of station 48, it is 350 feet below it. So we see there is a slope to the westward at present. We cannot tell whether this is the original surface, or whether it has been modified by subsequent erosion. It is probable, however, that the original slope was to the westward. We see the same decrease in elevation from east to west on the plateau between the North Fork of the Gunnison and Plateau Creek. On station 43, which is one of the most eastern of the basaltic points on this plateau, the elevation is 11,134 feet. At station 44, one mile farther west, it is 11,128, while on station 45, eight and a half miles west of station 43, it is only 10,954, a decrease of 180 feet. Five miles west of station 45 the elevation is 10,904, which is practically the same as that of station 45. Sixteen miles west of this point, at the north end of the mesa, the elevation is only 9,800 feet, and at the south end, which is three and a half miles farther east and sixteen miles south of the north end, it is 9,733 feet. This is a fall of a little over 1,400 feet from station 43, in a distance of about twenty-seven miles. The greater part of the decrease in elevation is in the western portion; that is, in the last twelve miles. As is evident, on glancing at the figures given above, the eastern portion varies but little on comparing the higher points with each other. About stations 43, 44, and 45 the basalt forms points that rise considerably above the general level, while the surrounding country is very much broken up. To the westward, however, the basalt forms a mesa-like capping to the country. This mesa is somewhat irregular in outline, forming at first a narrow strip which divides into two arms, one extending to the southwest and the other to the northwest. They are separated by a small creek that drains into the Gunnison. It has cut gradually deeper and deeper until the basaltic capping has been removed, leaving a tongue-like process of Tertiary rocks between the arms.

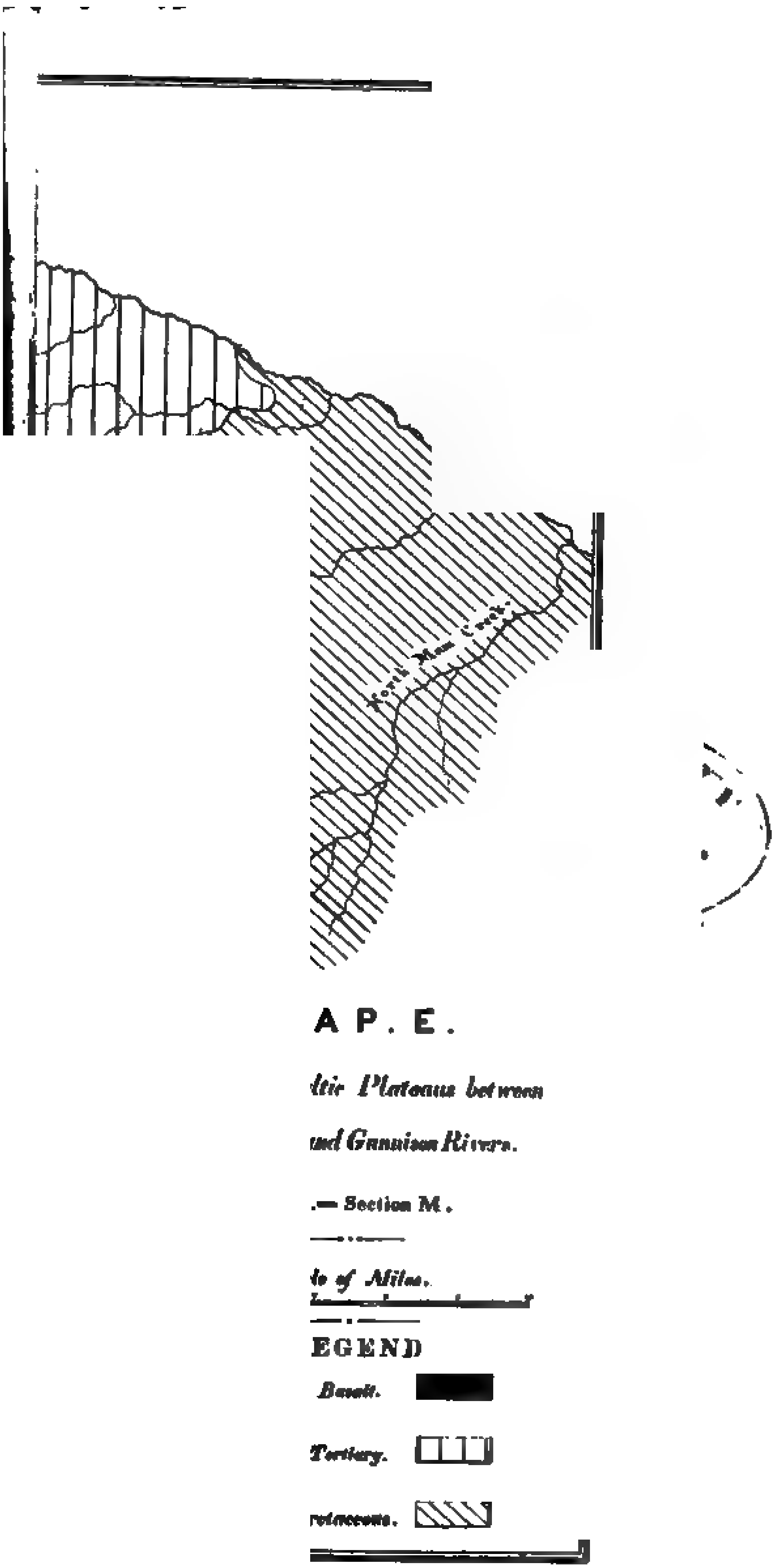
In the eastern part of the divide the areas covered with basalt are

irregular. The highest points in these areas hardly mark the origina surface of the flow. The subsequent denudation has been enormous, a will be readily conceived when we compare the elevations of thes points with those of the deepest valleys near them. Stations 45 an 48 are almost on a line with each other running north and sout This line also passes through our camp No. 45 which was on Platea Creek. Comparing the elevations of these three points we find that th creek at camp 45 is 3,801 feet below station 48, and 3,870 feet belo station 45. Farther down, the distance from the north end of the me to the level of the creek is over 4,000 feet. The south end of the me is 4,677 feet above the level of the Gunnison at a point due south of These figures will give some idea of the immense amount of materi that has been removed since the flow of lava took place, and show al how improbable it is that the original surface still remains.

The two plateaus that we have just described are evidently the remai of what was once one continuous mass. The elevation of station 48 practically the same as that of station 45. On comparing the roc from the two localities, we find that they are identical in appearan and in structure. We have also seen that there is the same slope the west on both. If they had not been connected we would find trac of the flow in some of the valleys, but we search in vain for any su evidence. No basalt is seen in the valleys save the bowlders that ha been carried down from the plateaus. What the original limits were is impossible to tell.

It is difficult to get at the exact thickness of the basaltic flow originally spread out. At present it is probably considerably le At station 48 the total thickness is 248 feet. This is the highest poi on that plateau but it hardly represents the original thickness. T thickness at the north end of the mesa is 100 feet. The latter may n be absolutely correct. It was determined from station 57 by angles the top and base of the abrupt wall of the mesa. The actual ba may be covered with the talus so that it is concealed. As to the a and the source of the basalt we cannot say anything very definite. is, however, in all probability comparatively recent, although older th the flow mentioned as occurring near the mouth of Eagle River. rests on sandstones and shales of Tertiary age, which were but lit affected by erosion previous to its pouring out. I was unable to fix any point as its source; I think, however, that it lies farther to t north. The surface of the plateaus is covered with good grass, a groves of cottonwoods and pines, among which there are numero beautiful little lakes. Both of them are very well watered. Ne station 45 are three beautiful lakes, two of which head streams flo ing to Plateau Creek, and one heading a branch of the North Fork the Gunnison. Near station 45 there is a beautiful illustration of t effects of cooling, in the hexagonal columns into which the mass h separated. They are very regular, and are five or six feet in diamet The surface of the mass inclines to the northward.

The edge of the mesa portion of the plateau is very abrupt, especia on the western side, and at the extreme northern and southern en It stands out like the wall of a fortress. The outline is irregular. T accompanying map will give a good idea of it as also the areas cover by the basalt. Fig. 3, Plate IX, shows a section made from the ed of the mesa to the Gunnison. On the line A B of map E, a represe the capping of basalt. In all the valleys of the streams headi in the mesa there is an abundance of bowlders of basalt. They are numerous in some places, even on the long sloping spurs running fr it, that it is difficult to determine the underlying rock.


A P . E .
ltic Plateaus between
and Gunnison Rivers.
— Section M.
le of Miles.
EGEND
Basalt.
Tertiary.
retaceous.

CHAPTER IX.

ECONOMICAL GEOLOGY.

The greater portion of our district, with the exception of the area along Eagle River, lying within the limits of the Ute reservation, of course no mining operations can lawfully be carried on. Indeed, the areas in which mineral-deposits are found are limited to the group of mountains in the southeastern part of the district, and to the gneissic rocks about the head of the Eagle. The remainder of the country is covered with sedimentary rocks, mostly of Cretaceous and Tertiary age, in which mineral-deposits are rare. Lignite is found, but, with the exception of that near station 34, it is of poor quality.

GOLD.

On Eagle River we met a party of prospectors who claimed to have found gold in placer diggings in paying quantities on some of the streams flowing into the Eagle from the south, below the mouth of the Piney, and above the second cañon.

On the North Fork of the Gunnison, southwest of station 26, we met another party, who said they tried the dirt, and that the colors were good.

SILVER AND LEAD.

The Elk Mountain mining district was described in the report for 1873. The ores are mainly silver-bearing galena. There are doubtless numerous lodes similar to them at various points around the heads of Slate River and Rock Creek. We did not have time to make a detailed survey here. The rocks are penetrated in all directions by dikes. At the head of "Oh be Joyful" Creek, east of station 32, Mr. Holmes got a specimen of galena associated with pyrites. On the other branches ledges would probably be found on searching for them, as the rocks are similar.

COAL.

Lignite is found at several points in our district. At the mouth of the Gunnison, and in the bluffs on the river from the mouth to the mouth of Roubideau's Creek, it is seen, but of poor quality. This lignite is of Cretaceous age, being found in the sandstones of the Dakota group.

On Coal Creek, a branch of Anthracite Creek, a bituminous lignite is found in sandstones, which I have referred to the Upper Cretaceous. Two specimens from this creek were examined, with the following results:

Analysis.

	Specimen No. 1.	Specimen No. 2.
Water	5.04	36.02
Volatile matters	31.46	
Carbon	59.50	59.68
Ash	5.00	4.30
	100.00	100.00

This coal is black (brownish-black in powder), has a dull luster, and an irregular fracture. The ash is of a light-reddish color. The analyses

show that the coal compares favorably with the lignites found in other parts of the West.

Anthracite Creek.—In the report for 1873 I spoke (page 259) of the occurrence of anthracite coal in the Elk Mountains. It is found at the heads of Rock Creek, Slate River, Anthracite Creek, and Ohio Creek.

It is probably all of Cretaceous age, and was doubtless originally a bituminous lignite. The coal at the head of a small branch of Anthracite Creek was found in a bed from 4 to 5 feet thickness in sandstones. The section has been given in a preceding chapter. These sandstones were tipped up against a range of trachytic peaks, and between the layers of sandstone, some distance above the coal, is a layer of trachyte. The strata dip at an angle of 20° to 25°. This coal is probably a portion of the same bed from which the coal on Coal Creek was obtained, although in the latter case it is lignitic. The eruption of the trachyte found near the coal first mentioned probably so heated it as to deprive it of the bituminous matter. This coal from the head of Anthracite Creek has a submetallic luster, is black even in powder, and has a conchoidal fracture.

Analysis No. 1.

Water	2.00	4.50
Volatile matters	2.50	
Carbon		91.90
Ash (of a dark reddish-brown)		3.60
		100.00

Analysis No. 2.

Water	1.60	5.00
Volatile matters	3.40	
Carbon		88.20
Ash (same as No. 1)		6.80
		100.00

These analyses prove the coal to be of excellent quality. Neither of the specimens coked. The percentage of water and volatile matters and the amount of ash compare favorably with other anthracites.

Oh be Joyful Creek.—The coal on this creek is also an anthracite. It was discovered in 1874, and the following notes were obtained from Mr. Holmes, who visited the bed. It is two feet in thickness, between beds of quartzitic sandstones and metamorphosed shales, which dip slightly to the west. The coal outcrops about 1,500 feet above the level of Slate River at the mouth of the creek, two miles up the stream. This coal probably belongs to the same horizon as the coal on Anthracite Creek and on Rock Creek. It probably outcrops again at the head of Slate River. A specimen collected by Mr. Holmes has a submetallic luster, is black, with rusty-colored surfaces from the presence of iron, a fracture somewhat cuboidal, breaking also into layers. This coal seems to be of poorer quality than that of Anthracite Creek and Rock Creek.

Analysis.

Water	4.00	18.00
Volatile matters	14.00	
Carbon		74.00
Ash (of a reddish color)		8.00
		100.00

It would perhaps be more properly described as a semi-anthracite. The sandstones and shales surrounding it are penetrated by numerous dikes and mineral lodes.

Rock Creek.—The coal on this creek is also an anthracite. It is found in Cretaceous shales beneath a mass of trachyte. The shales represent a horizon at least 3,000 feet above the Dakota group. The bed is 5 feet thick.

The following is an analysis of the coal. It has a brilliant luster, conchoidal fracture.

Analysis.

Water and volatile matters	7.4
Carbon	88.92
Ash, (reddish)	3.68
	100.00

The following is an analysis of coal from this region (probably from Rock Creek) by Professor Mallet, of Colorado:

Analysis.

Fixed carbon	91.02
Ash of dark-brownish color	5.30
Volatile matters, chiefly water	3.68
	100.00

The analyses given above show a decided advantage over the lignites found in other parts of the Territory, and their occurrence in the midst of so many deposits of galena, nearly all of which is probably silver-bearing, will probably in the future have a decided and important bearing upon the mining operations that may be carried on in this region. The following table gives the comparison of average percentages of constituents of the Elk Mountain coals with those of anthracites and other varieties, of both foreign and domestic. It will be seen that the coals of which analyses have been given above rank high in the comparison.

Variety.	Average of water and volatile matters.	Carbon.			Ash.			Remarks.
		Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
Foreign anthracites	3.537+	92.56	87.96	90.49	9.31	1.58	5.935	4 analyses, taken from Dana's Mineralogy; localities, South Wales and Hanover.
Pennsylvania anthracites.	5.811	94.10	80.57	88.046	9.25	2.90	5.348	7 analyses, from table in Rogers's Geological Survey of Pennsylvania, volume ii, part ii.
Pennsylvania semi-anthracites.	10.106	90.23	74.55	82.070	12.30	2.70	7.661	10 analyses, from table in Rogers's Geological Survey of Pennsylvania, vol. ii, part ii.
Anthracites from the Elk Mountains, Colorado Territory.	**7.726**	**91.90**	**74.00**	**86.804**	**8.00**	**3.68**	**5.476**	**Result of 5 analyses given above in the chapter preceding this table.**
Pennsylvania bituminous coals.	28.222	70.68	56.80	71.756	11.75	2.07	5.762	10 analyses, from table in Rogers's Geological Survey of Pennsylvania, vol. ii, part ii.
Foreign bituminous	....	89.27	75.59	81.126	8.60	1.41	3.694	10 analyses, taken from Dana's Mineralogy.
Ohio coals	36.65	64.20	53.50	58.10	13.00	1.80	5.12	20 analyses, from Newberry's Geological Report of Survey of Ohio for 1873.
Indiana coals	42.21	59.00	43.50	51.20	18.50	2.09	6.02	52 analyses, from Geological Report of Survey of Indiana for 1873.

Variety.	Average of water and volatile matters.	Carbon.			Ash.			Remarks.
		Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
Illinois coals	41.09	64.90	47.50	52.992	9.60	2.00	6.248	10 analyses, from Geological Report for 1873, Survey of Illinois.
Iowa coals	47.81	......	......	45.42	......	......	6.77	From table of 64 averages of coal analyses, in Geological Report 1870, Survey of Iowa, White.
Missouri coals	41.443	79.28	27.72	40.816	19.97	2.05	9.026	111 analyses, from Geological Reports for 1873-'74, Survey of Missouri.
Foreign lignites or brown coals.	31.596	71.71	47.46	60.414	14.95	0.59	7.521	10 analyses, from Dana's Mineralogy.
Lignites of Colorado and New Mexico.	41.284	59.72	44.44	52.384	20.20	2.00	5.616	14 analyses, from table of proximate analyses of lignites, Report of A. R. Marvine, United States Geological Survey, Report of 1873.
Lignites of Wyoming Territory.	40.972	54.46	47.04	51.216	9.60	1.73	5.331	10 analyses, from Report of A. R. Marvine.
Lignites of Utah Territory.	52.418	46.84	36.35	43.035	7.50	0.97	4.553	6 analyses, from Report of A. R. Marvine.
Lignites of California	53.613	58.32	47.83	49.631	4.01	2.96	3.395	10 analyses, from Report of A. R. Marvine.
Lignites of Montana and Oregon.	47.224	64.18	41.98	49.34	12.00	3.19	7.036	5 analyses, from Report of A. R. Marvine.
Lignites of Vancouver's Island and British Columbia.	44.468	51.81	45.44	47.552	18.55	2.15	6.24	

The excellent tables and notes on the western lignites in Mr. Marvine's report for 1873, and the notes on the lignites east of the mountains in the reports of Dr. Hayden and Mr. Holmes, preclude the necessity of any further remarks here.

GYPSUM.

Gypsum is the only remaining mineral of economical importance in the district. The localities and general description have been given in previous chapters. It occurs in quantity on Eagle River and Frying-Pan Creek.

The list of minerals given in the catalogue accompanying the report is, of necessity, small, the sedimentary formations prevailing in the district, being sandstones mainly of Cretaceous and Tertiary age.

CATALOGUE OF MINERALS NOTED IN THE AREA ASSIGNED TO THE SECOND OR MIDDLE DIVISION, UNITED STATES GEOLOGICAL SURVEY, IN 1874.

AGATE. Cloudy, of white, brown, and gray colors, on the plateaus between the Grand and Gunnison Rivers. *Moss Agate*, of poor variety, in the valley of the Gunnison River, west of the mesa, near the Grand.

AMPHIBOLE. *Hornblende* in small needle-like crystals, in some of the

rocks in the volcanic breccia, near station 31, at the head of west fork of Ohio Creek.

CALCITE. In the Cretaceous rocks on Grand River and on the Gunnison River.

COAL. *Bituminous lignite* on south fork of Anthracite Creek. *Anthracite?* on Anthracite Creek. A poor quality of lignite is found also in the bluffs at the mouth of the Gunnison.

FELDSPAR. Undetermined varieties in the schists at the head of Eagle River and in the Grand Cañon of the Gunnison. *Sanidine* in the rhyolites and obsidian on the Gunnison River. Trachytes of Elk Mountains.

GOLD. Said to occur along the upper part of the north fork of the Gunnison and head of Eagle River.

GYPSUM. In the gypsiferous sandstones on Eagle River and on Grand River and Roaring Fork. In the Cretaceous strata of Grand River and the Gunnison.

CHALCEDONY. *Blue* variety, lining cavities in the rhyolites on Gunnison River, above the Grand Cañon. *White*, in valley of Gunnison, west of mesa, above the Grand.

HYALITE. In the basalt on station 48, near station 73, on Gunnison River.

HORNBLENDE. (*See Amphibole.*)

JASPER. Red in color, in chips on the plateaus, between the Grand and Gunnison Rivers. In nodular limestone in the bluffs on Gunnison River near station No. 60, also near station 73.

LIMONITE. Near the head of the south fork of Anthracite Creek.

MICA. Undetermined variety, probably *Muscovite*, in schists of Eagle River and Gunnison River. Brown variety in rhyolites in Gunnison River.

OBSIDIAN. Beneath the trachyte on Gunnison River, above the Grand Cañon. It is both porphyritic and spherulitic.

PYRITE. Octahedral crystals near station 32, Anthracite Creek. Coating surfaces of basalt, near station No. 48.

QUARTZ. In the schists of Eagle River and the Gunnison; *crystals* in the Cretaceous rocks near station No. 32, at the head of Anthracite Creek.

SANIDINE. In the trachytes of station 32, station 30, station 34, &c.; also, in the obsidian and rhyolite on Gunnison River, above the Grand Cañon.

SELENITE. In the gypsum beds of Eagle and Grand Rivers. In the Cretaceous shales at various points along the Gunnison River.

TREMOLITE. In radiating crystals in the porphyritic trachyte on station No. 38.

LIGNITE. (*See Coal.*)

CATALOGUE OF ROCKS COLLECTED IN 1873 BY A. C. PEALE, MIDDLE DIVISION UNITED STATES GEOLOGICAL SURVEY.

No.	Name, &c.	Locality.
1	Porphyry	Mines on Mount Lincoln.
2	......do	Do.
3	......do	Do.
4	Gray siliceous sandstone (Cretaceous)	Station No. 6, on Eagle River.
5	Motled limestone (Cretaceous?)	Below station No. 7, on Eagle River.
6		South of Eagle River, near station No. 6.
7	Selenite	Near the junction of Eagle and Grand Rivers.
8	Gypsum	Do.
9		North side of Eagle River, near its mouth.
10	Greenish sandstone (Cretaceous?)	Station No. 26, west of Rock Creek.
11	Gray sandstone, Cretaceous	Anthracite Creek, near Mount Marcellina.
12	Greenish sandstone	Do.

Catalogue of rocks collected in 1873 *by A. C. Peale, &c.*—Continued.

No.	Name, &c.	Locality.
13	Porphyritic trachyte, from dike in sandstones	Anthracite Creek, near Mount Marcellina.
14	......do	Do.
15	Porphyritic trachyte	Mount Marcellina.
16	......do	Do.
17	Brown trachyte ? from breccia	West Fork of Ohio Creek.
18	......do	Do.
19	Dark greenish trachyte ? from breccia	Do.
20	Light reddish tufa from breccia	Do.
21	Black trachyte ? from breccia	Do.
22	Greenish trachyte ? from breccia	Station No. 31, near the head of West Fork of Ohio Creek.
23	Black trachyte ? from breccia	Do.
24	Dark gray trachyte from breccia	Head of West Fork of Ohio Creek, below station 31.
25	Light gray hornblendic trachyte from breccia	Do.
26	Greenish laminated trachyte from breccia	Do.
27	Ashy-gray tufa from breccia	Do.
28	Trachyte ? (dike No. 1 in Cretaceous rocks)	Ridge southeast of Station No. 32, between head of branches of Slate River and Ohio and Anthracite Creeks.
29	Sandstone conglomerate	Do.
30	Trachyte (dike No. 2 in Cretaceous rocks)	Do.
31	Trachyte (dike No. 3 in Cretaceous rocks)	Do.
32	Trachyte (dike No. 4 in Cretaceous rocks)	Do.
33	Porphyritic trachyte (dike in Cretaceous sandstones above coal-bed).	Small southern branch of Anthracite Creek, near the head of the creek.
34	Porphyritic trachyte ?	Station 30, head of Ohio Creek.
35	Trachyte	Station 33, between the North Fork of the Gunnison and Rock Creek.
36	......do	Ridge below station No. 34, west of Coal Creek.
37	Trachyte (dike in Cretaceous rocks)	Coal Creek, near camp 36.
38	Sandstone (above dike)	Do.
39	Porphyritic trachyte	Summit of station 38, east of Smith's Fork of the Gunnison.
40	......do	Slope of station 38.
41	......do	Station 39, east of station 38.
42	Trachyte (dike)	North side of Smith's Fork, near foot of station 38.
43	Sandstone (above dike)	Do.
44	Red basalt ?	Station 40, north of the North Fork of the Gunnison.
45	Black basalt ?	Do.
46	......do	Station 42, between North Fork of Gunnison and branches of Grand River.
47	Black basalt	Station 45, northwest of station 42.
48	Argillaceous shale	Ridge leading to station 47.
49	Black basalt	Summit of station 48, south of Grand River.
50	Purplish basalt	Slope of station 48, south of Grand River.
51	Black basalt	Base of station 48, south of Grand River.
52	Amygdaloidal basalt	Do.
53	......do	Do.
54	Red vesicular basalt	Do.
55	Tufa	Do.
56	Black basalt	Top of mesa, near station 54, south of Grand River, north end.
57	......do	Top of mesa, near station 59, south end, east of Gunnison River.
58	Argillaceous shale (calcareous Cretaceous)	Bluff on Gunnison River, below station 60.
59	Whitish trachyte	Station 71, on Gunnison River.
60	Purplish trachyte	West of station 71, on north side of Gunnison River.
61	Porphyritic obsidian, with spherules	Do.
62	White tufa	Above station 73, on north side of Gunnison River.
63	Gray trachyte	Do.
64	Porphyritic obsidian	Do.
65	Purple vesicular rhyolite, with hyolite and chalcedony in the cavities.	Do.
66	Light trachyte	Do.
67	Purple trachyte	Station 77, on north side of the Gunnison, near the Grand Cañon.
68	Purple rhyolite	Do.
69	Tufaceous trachyte (in breccia)	Station 79, on south fork of Smith's Fork of the Gunnison.
70	Trachyte in breccia	Do.
71	Trachyte, greenish, in breccia	Do.

REPORT

OF

F. M. ENDLICH, S. N. D.,

1874.

WASHINGTON, D. C., *May* 15, 1875.

SIR: I have the honor herewith to submit my report for 1874. According to instructions received, I took the field July 14, 1874, as geologist of the San Juan division, and returned with it to Denver, Colo., October 19, 1874. During that time more than 3,000 square miles were surveyed topographically and geologically, including all that section of country known as the San Juan mining district. The very rugged character of the region, and the inclemency of the weather, impeded our progress somewhat, and the latter not unfrequently was a serious obstacle to the successful and speedy completion of the work.

Four chapters and a "conclusion" comprise the accompanying report. Some difficulty was experienced in finding a suitable basis for classification in arranging the material collected. The plan of dividing by formations was adopted finally. The first chapter treats of the metamorphic area, the second of the volcanic, the third of the sedimentary area. In the fourth chapter the geology and geognosy of the immediate vicinity of the mining region, as well as the mineralogical features of the mines, have been considered. A circumstance that will let this latter chapter perhaps appear somewhat unsatisfactory lay in the fact that the lodes discovered and claimed had in but very few instances been worked to any greater extent than was required by law to hold a good title. It was impossible, therefore, to study anything, save the surface characteristics. I beg leave to submit this chapter merely as a preliminary one, hoping to be able, at some future time, to make investigations upon the same subject when all conditions may be more favorable.

I wish here to express my thanks to Mr. A. D. Wilson, chief topographer of the San Juan division, and to Mr. F. Rhoda, his assistant, for their uniform kindness and courtesy during the field-season and in the office.

To Prof. F. B. Meek I am under obligations for the identification of fossils.

Hoping that this report may meet your requirements, I have the honor to remain your obedient servant,

FREDERIC M. ENDLICH.

Dr. F. V. HAYDEN,
Geologist in Charge, U. S. Geological and Geographical Survey of the Territories.

INTRODUCTION.

The district surveyed, topographically and geologically, by the San Juan division, during the field-season of 1874, lies between the 107th and 108th degrees of longitude west, and between 37° 15′ and 38° 15′ north latitude. Besides this, the party endeavored, by traveling down the Rio Grande to Del Norte, and from there eastward, to connect with some of the work of 1873, on the southern line of the district then surveyed. Two large rivers, the Rio Grande and the Rio Animas, head in the region explored, as well as a number of important smaller streams. Flowing northward, there are, beginning in the east, White Earth Creek, Lake Fork, and Uncompahgre Creek. Rio San Miguel and Rio Dolores flow in a westerly direction; Rio Animas, and its tributaries, Cascade, Arimosa, Junction, Florida, Vallecito, Pinos, and Piedra, flow south. Numerous small creeks help to complete a very perfect system of drainage throughout that section of country, admirable, not only so far as horizontal distribution is concerned, but also regarding the amount of water they carry.

As a rule, the character of the country is very mountainous, with numerous high and rugged peaks studding the mountain groups. It would not be correct to speak of ranges or mountain-chains in that country; the only appellation that can properly be given is that of a *group* of large extent. A marked change in the distribution of the higher elevations can be observed as soon as the sedimentary formations are reached, and it is there, that well-defined ridges, of limited extent, however, occur. Toward the north and west the mountains fall off steeply into the plateau country, while to the south the above-mentioned ridges serve as a transitory medium between the high and the low portions of the district. Near the southern limits of the region examined, the well-known "hog-backs" set in, identical in form with those along the Front range.

Numerous points of great beauty in detail can be noticed throughout the mountain regions just mentioned. Colors in great variety, exhibiting many shades, are to be observed in a number of localities, and greatly add to the effect produced by the sometimes almost ideal shape of peaks or ridges. The tendency of volcanic rocks, which compose the greater portion of our district, to weather in columns, gives rise to the formation of thousands of little pinnacles, not unlike Gothic architecture in appearance. Rugged and steep is the character of the mountain-sides, while numerous subsidences produced amphitheaters, with perpendicular walls, sometimes of considerable extent. Owing to the horizontal stratification of the volcanic flows, and to unquestionable ruptures of the strata, the influence of atmospheric agencies has sharply carved the outlines of peaks and small ridges in well-defined forms.

Geologically speaking, the variety offered is not so great. As stated above, volcanic rocks cover the larger portion of the area surveyed, while on the west and south sides of it the sedimentary beds set in. A group of metamorphic rocks occupies a prominent position, and is well marked by its sharp peaks and deep cañons.

Altogether, the region is one of very considerable interest to the

geographer as well as to the geologist. Although but little would be expected from the volcanic area to occupy the geologist's attention and satisfy his desire for new and interesting features, it was still found to possess so many unique characters that it could but be regretted that not more time dare be given to the study of detail structure and composition. Many points of importance must have escaped notice, because the rugged character of the country is such that much may be hidden to the eye of one who cannot command over an almost unlimited amount of time. It only remains to be hoped that subsequent explorations, carried out on a larger scale, may find and make known the numerous interesting localities that are as yet undiscovered. Large as the continuous volcanic area is, extending eastward into a portion of the work completed in 1873, its boundaries have not yet been reached. During the summer of 1875, the same party will have an opportunity of exploring the adjacent country to the south, and no doubt important facts will be observed during the survey.

In intimate relation with the geognostic features of the district surveyed, we find the distribution of the drainage. So marked is the difference appearing in the plotted sheets, that any one familiar with the general character of the country, might deduce from the horizontal projection of drainage the approximate outlines of geological formations. This would not be possible, were there extant there a large number of such formations, consisting each of numerous members, but as this is not the case, the deciding characteristics for each geognostic group are well defined.

CHAPTER I.

METAMORPHIC AREA.

The metamorphic area sets in south of the headwaters of the Rio Grande, at station 17, and from there continues southward for about twenty miles, eastward to its extreme limit for twelve miles. For four miles east of station 17 these rocks follow the course of the river, *i. e.*, more properly speaking, the course of the river is determined by them, and then they bend off southward again, for the same distance, influencing the course of a creek opposite Pole Creek. After that, their border runs in a southeasterly direction, inclosing all that high mass of mountains that we have designated as the "Quartzites." On the western side they approximately follow the course of the Rio Animas down to Animas Park, where the sedimentaries set in, occuring likewise also in the valley. As an estimate, it may be said that this continuous area of metamorphics covers three hundred and fifty square miles. A number of smaller patches of the same class of rocks occur at various other points, but are of less importance. The lowest portions of Cunningham Gulch contain a continuation of the area from station 17; northwest of the Rio Grande Pyramid (station 21), a coarse-grained granite crops out near a little lake. The cañon leading down northward from Handie's peak (station 14), contains a similar granite; on Lake Fork Creek, opposite station 12, granite again occurs, forming a few small hills, and it is found also around station 7, extending for some miles along the base of the ridge. In the lowest part of White Earth Cañon a schistose rock crops out, that must be referred to this group. It is overlaid by trachytes, and covers but a small area.

This large metamorphic group, from a geognostic and geological point of view, is one of the most interesting features that the district presented. Lithologically considered, almost every variety belonging to that class can be observed, although the mineralogical variations are not great. Near the northern border and toward the middle, quartzites and schists predominate, while granite appears toward the east and south. Mostly the quartzites are of a white or gray color, gradually becoming filled with mica or chlorite, thus turning into schists. Numerous small veins of white quartz traverse this rock, which must at one, or perhaps various times, have been subjected to considerable strains, whereby the small fissures were produced. At station 17 the rock assumes very much the character of a gneiss; the mica is black, quartz gray, feldspar whitish, but only little of it, texture and structure gneissoid. Going but a few miles to the north, this description will hold good no longer. Although for some distance volcanic rocks cover the schists, there is no doubt in my mind that the two—that of station 17 and that of Cunningham Gulch—are in connection with each other. The feldspar, however, and the mica have disappeared and are replaced by chlorite. Structurally there is no marked difference between them; it is expressed mineralogically only. Again, traveling southward from station 17, we first find a large quantity of a gray micaceous schist, rich in quartz, and soon, near station 25, the mica begins to disappear, so that we have a gray quartzite. This is the predominating rock throughout the highest por-

tions of the rugged group, that has therefrom received its name. Local variations occur quite frequently, but cannot be considered as the rule. Extremely varied and complicated we find the stratigraphical relations of these quartzites. The only fact that could be observed with any accuracy, and the only one that is of any direct value, is, that the anticlinal axis running through the sedimentaries farther westward, continues east through the quartzites, giving rise to the formation of some of the highest peaks in the group. In treating of this axis subsequently, this continuation will also be discussed, and the mention of it here shall suffice for the present. Eastward nearly as far as station 21, the quartzites retain their character as such, not changing into granite until near station 22. To the southwest of station 21 the quartzites dip regularly in a northerly direction, at an angle of about 16°, and are overlaid by trachyte No. 4, horizontally stratified, showing conclusively that certainly the later trachytic flows had nothing to do with the metamorphosis, or, at least directly, with the upheaval of the group. At some other points, which shall be mentioned hereafter, evidence was obtained that will exclude the trachytic eruptions entirely from causing any of the changes there observed.

Along this edge the quartzite is generally of a light grey or white color, containing interstrata of grey, fine-grained schists with twins and single crystals of staurolite. Mount Oso (station 23), reaching an elevation of 13,640 feet above sea-level, is within the quartzitic area, but some distance south of it schists again set in. Mr. Wilson noticed on that peak a fine-grained, white sandstone, in all probability the one that furnished the material for the formation of this quartzite. West and southwest of station 17, the same rock continues, liable to the same lithological changes as at other points. Station 38 is located on it, from where it extends southward for about eight miles more, when granite makes its appearance. The cañons cut into this quartzite are extremely precipitous and rough to pass through. Well-defined strata of the hard material form at their edges numerous ledges, which decomposing agents have in vain endeavored to level. Slides, partly snow-slides, partly rock-slides, have often polished the faces of the mountains, or sides of cañons, so as to preclude all possibility of ready ascent. Glacial action has also had its effect upon the walls, and is made more evident from the distribution of erratic bowlders. Of this we shall speak below. Owing to the compact structure of the strata, and the impenetrable character of the material composing them, but little of the precipitated moisture finds its way to any considerable depth. In consequence of this peculiarity, the creeks and streams, if even only flowing a few miles, are very swift and carry a large amount of water. Wherever the drainage has no rapid fall, so that the waters cannot flow off, it stagnates, and forms disagreeable swamps. Owing to the hardness of the rock, and the fact that it so well resists decomposition and disintegration, the *débris* slopes appear to be constantly balanced, and upon being disturbed, the disturber will not infrequently be greeted by an avalanche of the rocks descending toward him.

A number of large streams head in the Quartzite Mountains, and receive there a bountiful supply of water. Some of the largest are the Rio Florida, Rio Pinos, and Rio Vallecito, all of them tributaries of the Animas, and flowing in a southerly direction. One of the well-known local features that is produced by the steep character of the Quartzites is the Animas Cañon, several miles below Baker's Park. This cañon has very steep sides, and is generally considered impassable. At many points the transition of quartzite into mica schist or the reverse could be observed, but a lack of time did not permit us to follow this out in detail.

Could it have been accomplished, probably some very interesting facts might have been elicited.

Less in horizontal extent, but just as well marked in their structure, are the schists. Scarcely at any point were they found entirely free from bands of a more decidedly quartzitic character, but are generally easily distinguishable by their darker colors. They, too, show very much variation in dip and strike, owing, probably, to small local contortions and slides. A general dip northward on the one side of the anticlinal, and southward on the other, may be observed, however, and to some extent determines the outlines of the mountain-sides, their more or less precipitous character. As a rule they seem to be older than the granite, but it was not possible to establish this point beyond a doubt, as the above-mentioned disturbances have produced so many abnormal positions of the beds with reference to each other that it becomes a matter of great difficulty to establish their true relations. Schists were found at no other localities in the district, except in the Quartzite group, and a few points immediately adjacent. That they extend for some distance under the trachytes, I am very much inclined to believe, but it must be at considerable depth.

Near station 22, the granitic area sets in, continuing from there southward toward the sedimentary ridges. As a rule, the granite may be said to be coarse-grained, with two feldspars. In contradistinction to the quartzites the granites form less steep and rugged points, owing to the facility with which atmospheric agents act upon their mineral constituents. Southward this rock sets in, a short distance below station 23, and from there continues west to the Rio Animas, forming the bed of that river for about nine miles. All the granite in this southerly region shows a remarkably regular stratification, not only an apparent one, produced by the main cleavage-plane of the feldspar or mica lying in one direction. True to what was stated above, the dip of the strata is in conformity with that of the quartzites and schists, away from the anticlinal axis toward the south. Generally it is not very marked, but still reaches 7° to 10°. All along the Animas we did not observe the junction of the sedimentaries with the granite. The latter was exposed in the valley, while the former appeared in steep bluffs on either side. From the dips observed, however, it became evident that the two were conformable, and later in the season we had occasion to verify this fact. Owing to the stratification of this metamorphic rock, and furthermore to its gentle southward dip, it forms rounded bowlders, *in positu*, that bear a striking resemblance to the *roches-moutonnées*, but I am not prepared to regard them as such only.

It may be well to give the mineralogical characteristics of a few of the most frequently observed varieties of this granite before proceeding any further.

a is a coarse-grained variety, composed of orthoclase, oligoclase, mica, and quartz. The orthoclase is pink, translucent, sometimes in Carlsbad twins, and is the predominating mineral. No parallel arrangement of the main cleavage-planes can be observed. Oligoclase is white to light-gray, somewhat inclined to decomposition. Mica is black, very thoroughly mixed in with the other minerals, not crystallized. It is probably biotite, and assumes when decomposing a splendent brown color. Quartz is yellowish to gray with a decidedly greenish tinge. It is least in quantity as a rule. As an accessory mineral, magnetite may be mentioned. This variety is the one most frequently found, and extends, with local changes, certainly from station 22 southward to station 52, from there west, past station 48, over to the Animas. It weathers readily and forms sands and small irregular bowlders. *b*. Another variety

occurring at many localities, although not covering so extensive an area as the preceding one, consists of orthoclase, mica, and quartz. It is fine-grained, and has, on account of a comparatively large quantity of mica, a dark color. The orthoclase crystals are colorless, transparent, very intimately associated with the quartz and mica. This latter is dark-brown to black, showing single crystals. Quartz is white to colorless, sometimes grayish. In consequence of the compact texture, this rock successfully resists decomposing influences, and, wherever found, stands out more prominently than the one before described. *c.* A third variety differs from the two preceding in appearance as well as in quantitative composition. Orthoclase, quartz, and mica form the crystalline aggregate. The orthoclase is pink, translucent, occurring in very small particles, and is by far predominating in quantity. Quartz is colorless to gray, and the mica black, occurring very sparingly. In consequence of the fact that orthoclase forms the main bulk of the rock, it has a pink color, and looks in reality more like a crystalline mineral than like a compound of separate minerals. With reference to its position to the two varieties described above, it may be said that it occurs in bands or strata within the first one. Had it been feasible, it would have been extremely interesting and important to study the relations that these distinct varieties bear to each other, and to determine whether their relative position is constant under the same relative conditions.

A phenomenon of some interest was observed a short distance westward of station 22. Some of the trachytes, belonging to Nos. 2 and 3, have flown toward the Quartzites, but it appears that the latter may have been too high for them at the time, and they were not reached. At the point indicated, a very large mass of the volcanic material has fallen down perpendicularly for a distance of about 700 feet. This shows that at one time a cave must have existed there, as the possibility of the place having been underwashed is excluded by orographical features as well as by the physical character of the underlying rock. It has frequently been noticed, that at the junction of non-volcanic and volcanic rocks, caves were formed, and it seems probable that we have in this case an analogous occurrence of very considerable extent.

Besides this continuous granitic area there are the isolated points mentioned above. Near station 7, the granite is coarse-grained, with orthoclase only, readily decomposing. Near Lake Fork, opposite station 12, and at Handie's Peak it is very coarse, with large crystals of orthoclase and white oligoclase. On the ridge near station 21 it is of the same character, with a large percentage of black mica, giving it upon first sight the appearance of syenite. At all these localities it is exposed for a short distance only, being covered by the overlying trachytes. The irregularity in the elevation of these outcrops points to the fact that either the volcanic disturbances must have had a very marked effect upon the material the lava penetrated, or that prior to them already the configuration of the country was a much varied one.

I am more inclined to the latter view, from the fact mainly that we find such a very considerable thickness of the volcanic strata at numerous places, while at others, although the difference in absolute elevation would not warrant it, this thickness dwindles down to a merely nominal figure compared with the former.

A question of considerable interest, and at the same time one that I believe can be satisfactorily answered, is that touching the origin of this metamorphic group. Along the northern and eastern borders of the area covered by the rocks of this series, no evidence was obtained that would furnish a satisfactory clew to the answer. On the northwestern and southern edges, however, several points were found that

decide the question beyond a doubt. Station 48 is located on an isolated patch of Upper Devonian limestone, surrounded on all sides by granite, answering in mineralogical description to the first one above given (*a*). The Devonian strata are deposited on the granitic strata conformably, both dipping south 15° west, with a dip of from 4° to 6°. Traveling southward from station 48 toward station 49, we pass for nearly a mile through a lower sag, the bottom of which is formed by granite. Rising slightly on this granite, a steep bluff is soon reached, composed below of hard quartzites, with sandstones and limestones higher up. All the strata dip conformably with the well-defined strata of the granite, in the direction and at the angle indicated above. From the quartzite into granite the transition is very perfect, although even small specimens can be found showing on the one side granite, on the other a granular red quartzite. Near the top of the bluff the latter is white or yellowish, becoming red and brown lower down. Finally some mica is observed in it, and the feldspar appears as such, until the coarse-grained granite is reached. The metamorphosis is very thorough, and can be admirably studied at this point. So far as I could decide, the granite was formed out of a partly argillaceous sandstone, containing some iron in an oxidized state, while the purer sandstones were turned into quartzites. Probably the process of metamorphosis was a very slow one, and lasted a long time. Throughout the stratification is well preserved in all the rocks of that group, but particularly so in the granite of the locality just described. Even the thicknesses of the various strata which have been altered into granite, correspond approximately to those at present exhibited by the superincumbent beds. At that point, *i. e.*, a short distance north of station 48, the granite overlies the dark schists, which in turn seem to be younger than the true quartzites forming the main bulk of the mountains still farther north. Another locality was observed, where the metamorphics showed their intimate connection with unchanged sedimentary beds, although not so clearly defined as at station 48. West and southwest of station 38, on the west side of Animas Cañon, there appears in the ravine below the station a coarse-grained, white sandstone, that, from stratigraphical reasons, I refer to the Upper Silurian. By following out the course of this sandstone, it will be found that it gradually changes into a white and gray, very compact quartzite. To establish the precise locality where this change occurs, I did not succeed.

Besides this direct evidence, pointing to the origin of the metamorphics under consideration, their geognostic features are similar, in fact at many places identical, with those that sedimentaries would have exhibited under the same circumstances. Not at any point along the border of this group did we find rocks that were older than Devonian, with the exception of that white sandstone near station 38. Taking into consideration, therefore, the observed conformity of the underlying metamorphics with the overlying sedimentaries; taking into consideration, furthermore, the analogous character of stratigraphical relations, the conclusion must be reached that those sedimentary beds, which existed below the Devonian, furnished the material for the metamorphic masses. The presence of the sandstone near station 38, which was not observed at any other point, speaks for the existence at one time of sedimentary beds below and conformable with those we now find. Almost, if not entirely, the Silurian has disappeared, and at some localities only the highest strata of the Upper Devonian remain, while at others many hundred feet are yet unaltered. Altogether the region is of the highest interest, and it can only be regretted that very unfavor-

able weather and a lack of time prevented us from spending as much time there as we should have wished to expend upon it.

Another characteristic of that group dare not be overlooked, as its consequences have a more or less direct bearing on geognostic features. Owing to the position that this high mass of peaks takes to the adjoining low country, rain or snow fall is very frequent. During the entire summer, whenever we had a view of that section of country, it could almost invariably be noticed to rain or snow, and during our trips through its mountains we had ample opportunity to verify the observations made from a distance.

It is apparent that, in a case of that kind, glaciers might form that would have considerable influence upon the shaping of the configuration in detail; although the falling of *débris* will frequently produce results similar to those furnished by moving ice. A number of points were observed where the rounding off and striation of the sides of cañons or gorges, and the deposition of large, washed bowlders, left no doubt as to their origin. This was observed particularly well on the headwaters of Vallecito Creek, northwest of Mount Oso (station 23). Near station 38 another locality showing the effects of glacial action was observed. The hard quartzite strata exposed their edges, having a dip of about 23° to the northwest. From the north and south ridge upon which the station was located, the ice had come down, rounded off all the sharp edges of the quartzite strata, and had polished and striated such portions that were too high to be covered. Three or four of these small glaciers must have moved side by side, separated by narrow ridges. Toward the main ridge the ground is scooped out deeper than some distance from it, and the heads of the upturned strata are worn away more at the end facing it. Numerous small lakes, or, in some places, swamps, are found in the holows produced by the passage of ice and rocks.

As mentioned above, some of the granitic rocks in the Animas Valley, above Animas City, have the characteristics of *roches-moutonnées*. Below Animas City there is a narrow valley about one and a half miles wide on average, and ten miles long, the Animas Park, so-called. The soil of this valley is composed of drift, originating to great extent in the granitic areas. Although I should not be prepared to attribute its presence entirely to glacial action, it seems probable that the ice-masses, which certainly existed at one time higher up along the river, might have extended, at least periodically, downward, and thus may have added their share to the transportation of erratic material. As is always the case in a comparatively level valley, where the character of the river-bed offers but little resistance to the eroding influence of flowing water, here, too, the river gradually meanders through it in many curves, and it cannot be denied that the action of the waters alone carried perhaps repeatedly over the same ground would be fully able to produce the result observed.

In a country where the winters are very severe, where the precipitation is considerable, and where the character of the mountains and cañons is so singularly favorable to allow by far the greater part of the water to flow off, local temporary glaciers may be formed more readily than where the cited conditions are wanting. Should this be continued for any length of time, the result will be a series of phenomena analogous if not identical with those observed in regions where persistent glaciers exist. The absence of any well-developed moraines at the localities just described, inclines me to the view that such may have been the case in these instances.

CHAPTER II.

VOLCANIC AREA.

By far the greater area of the district surveyed during the summer of 1874 is covered by volcanic rocks. Nearly 1,800 square miles of volcanics join on to the region of 1,400 square miles which were reported upon the year previous (Report United States Geological and Geographical Survey, 1873). It is evident that, where so large a mass of volcanic material was ejected and spread over the country, that innumerable varieties will be found, and considerable difficulty will be encountered in the attempt to reduce all the observed occurrences to features already well known.

Orographically this area may properly be divided into three definite systems—into the—

Plateau country,
Bluff country, and
Mountain country.

The first, the *Plateau* country, rises to considerable elevations, averaging about 12,700 feet above sea-level for the summit. Geognostically the latter are mostly composed of basalt, although trachyte plateaus are not wanting. Stations 3, 4, and 5 are located on plateaus of this character, and may serve as types. Sloping off to the east, veering around in that direction to the north and south, they present very steep sides on the west and toward the south. Owing to the high elevation, their summits are barren, only the rocky *débris* covering them. Analogous in appearance, but varying from them in every other respect, is the—

BLUFF COUNTRY.

As such, I mean to designate all those sloping ridges that have been formed by very extensive flows of the volcanic material, show a plateau-like summit, but rarely reach the elevation of those before described, nor the horizontal extent. In contradistinction to them they are invariably formed by trachytic flows. Deep and precipitous cañons cut through them, partly the result of separation by strain, partly by erosion. To this class all the lower regions of our district belong. Frequently they are densely wooded, or show grassy flats. As a type, the regions on either side of the Rio Grande, between Lost Trail Creek and Antelope Park, might serve, varying in elevation from 10,000 to 12,000 feet.

THE MOUNTAIN COUNTRY

comprises all the western and northwestern portion of the district, where the highest elevations were found, upward of 14,300 feet, and which present the most rugged aspect. It is here that the volcanic rocks reach their highest development, their greatest thickness. Regularly stratified, the mountains are separated by narrow but deep cañons, containing swift mountain-streams. This section, too, will comprise all

the ore-bearing regions of the San Juan mining district, and from there over to Mount Sneffels (station 33). While the orographical character is sufficiently precipitous, there is not that regularity which can be observed in the country of long-continued, more uniform flows—in the bluff country. Although here, too, single strata may be traced without difficulty for miles, as well as in the former, the mountains or groups containing them are mostly separated by deep ravines, and the continuity of the stratum is not so apparent at a glance. The flows that form the highest peaks have been of much greater thickness, occurring at a time, probably, when the bluff country was too high to be reached, but subsequent disturbances, upheavals, and depressions have endowed the region with a wild, grand character. No regularity in the arrangement of the higher portions can be observed, no chains or regular systems of mountains. Taking the entire high volcanic country into consideration, it cannot be termed otherwise than a group. Upon the stratigraphical relations of this group—for the flows are so regular in their succession that we can treat them as strata—more will be said below.

In the drainage, too, of the district, the difference between at least the bluff and the mountain country can be observed. While, in the former, the streams run a more regular course, one more nearly approaching the straight line, the creeks and streams of the latter make numerous turns and curves, probably being forced to do so by the primary distribution of the mountains, and not the reverse, that the mountains owe their first form and present condition altogether to erosion. Numerous places may be found in this volcanic section where large masses of rock have fallen down, at times, for several thousand feet, and are now lying immediately below the perpendicular cliff that their falling produced.

In speaking of this volcanic area, it will probably be best to divide it according to its drainage, and after the discussion upon that plan is finished, give the most interesting and instructive points in detail. A consideration based upon the several strata that are defined below, might prove satisfactory were it not for the circumstance that so many streams, mountains, and other localities of the region in question, have thus far not been supplied with names. Accordingly, therefore, the main streams and their tributaries will be utilized as a means facilitating classification.

The Rio Grande, from its head-waters eastward to Del Norte, runs entirely in volcanic material, as well as all its tributaries from the north, while some of its southwestern ones head in the quartzite regions. White Earth Creek and all its tributaries are within the volcanic area so far as surveyed during 1874, Lake Fork and Uncompahgre Creeks are almost entirely within the limits of this area. Of the Rio Animas only the head-waters enter into consideration this time.

Traveling over so large an area of these formations, it soon became apparent that a certain regularity existed among the various members comprising the entire system of volcanics. Inasmuch as the flows were well defined, the breccias easily recognizable, and both could be traced for, sometimes, considerable distances, the idea presented itself to separate the best-characterized groups, and giving them numbers (analogous to the numbering of sedimentary formations), thus facilitate both description and subsequent classification. The absence of well-defined propylite and andesite, the two oldest eruptive rocks of the Trachorheitic group, is somewhat astonishing, but it seems, from evidence, that the eruptions of the material in our present district were later than those of the 1873 district. Besides the large, continuous mass we are

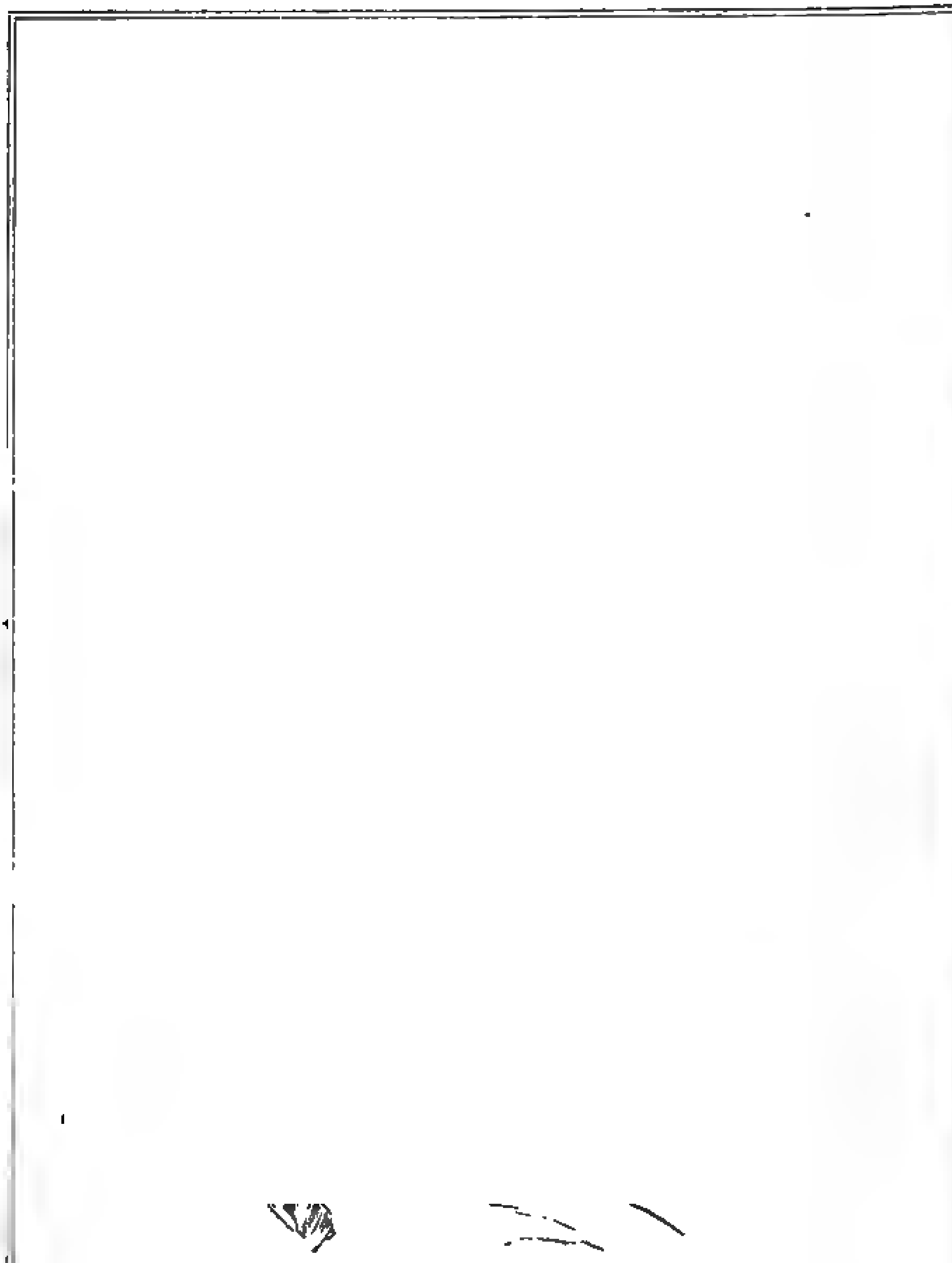


FIG 1.—"MONUMENTS" NEAR CAMP 23, EAST OF STATION 10.

speaking of at present, there are a number of isolated ones, but nowhere were the two rocks just mentioned met with. It seems that the magma which upon cooling produced our present trachyte, was existing in enormous quantities and gave rise to the numerous varieties that now reach altogether a thickness of 7,000 to 8,000 feet. Throughout the entire mass the trachytic character is constant, changing locally, however, on account of reheating, perhaps. As usual, the tuffs and breccia incident to the formation of the trachyte are found. Were it not for the surprising regularity manifested both in a horizontal and vertical direction, the correct recognition and classification of the many varieties under consideration must necessarily be rendered extremely difficult; altogether impossible for the short time that we could spend among them. The schedule based upon observation of the various strata at numerous points will give a general idea of the vertical distribution. Single features of the same strata were found to be of great regularity and materially aided in the identification.

No. 1 is very readily distinguished by the variegated appearance produced by a succession or change of different colors. Frequently the white, grayish, or yellowish colors predominate, but pink, red, green, and almost black are not wanting. In general appearance the members of this number present the characteristics of a series of "variegated marls." They form steep walls, weathering in small columnar masses, or they show smooth, rounded bluffs, the colors of which are beautifully blended. Should any isolated hard strata be contained in the series, they will show themselves as small monument-shaped projections on the face of the bluff, or weather in such forms that the play of fancy can readily picture them as imitations of animate beings. Water-courses cut deeply into the loosely-cemented material, and aid in forming the picturesque groups that may often be observed. On one of the branches of Lake Fork Creek a very curious group of "monuments" was observed in the trachyte of this number, illustrated by the accompanying cut. From the high plateau upon which stations 3 and 4 are located, broken fragments of basalt have rolled down the steep hill and found a resting-place on a small grassy slope near the creek. Heavy rain-storms gradually eroded the soft underlying material. This, protected in the vertical direction by the basalt block, assumed a columnar form in course of time, affording a sufficiently large resting-place to the rock that has produced this striking result. At the time of our visit, there were quite a large number of these "monuments" clustered together in a ravine that had been thus washed out. With the progress of erosion, the top of the conical pedestal holding the heavy block must assume a still more conical shape, and the latter will fall. Several of these columns were between twenty and thirty feet high. Differing from those in Eastern Colorado, these monuments do not show smooth sides, but a corrugated surface, produced by the constant dripping of rain during storms and other similar reasons.

This trachyte No. 1 reaches an average thickness of about 800 feet when fully developed. It might properly be termed a tuff, although at times layers occur in it that would forbid any such appellation if found isolated. Generally the material composing this series of strata is a light feldspathic aggregate loosely cemented. At some points larger fragments are found among the smaller ones, but all show alike the tendency to rapid decomposition. The numerous colors that frequently [illegible] are due to oxygen compounds of iron mainly. At some points, [illegible] the next stratum above seems to have reached No. 1 in a heated [illegible] the upper members are baked and contain jasper and semi-opal.

The group is very characteristic and sufficiently constant in its appearance to be recognized; must not, however, be mistaken for some of the local accumulations of tuffs that occur in higher trachytic beds.

No. 2 does not show so many variations as the preceding number. Mainly forming either low plateaus, grassy or wooded, or appearing in long, narrow ridges, it covers that section of country along the lower tracts bordering upon the streams of the eastern part of the district. Frequently cañons are cut through it, and then the walls are mostly very steep. In color, it shows but little variation. When freshly broken it has a pink tint, but upon exposure to atmospheric influences becomes brown. Near the border of the volcanic area, it is the formation most frequently met with. Toward the upper strata (there are only few in this group), bands and nodules of porphyritic pitchstone, and of obsidian set in, running parallel to the stratification of the trachyte. At times they are several feet thick, but rarely extend for any distance. Between stations 21 and 22, however, one band was found, from four to eight feet thick, that extended for several miles. Twelve hundred feet may be considered the average thickness for these strata, the most continuous and easily-traced ones of the entire series. The rock generally contains a great many small crystals of sanidite; crystals of black mica are dispersed throughout the entire mass. At some localities narrow prisms of hornblende occur, dark green to black in color. Upon exposure the mica assumes a splendent bronze color.

No. 3.—This group can readily be distinguished from No. 2 by the darker colors shown in its lower member, and the lighter ones its higher strata exhibit. In some localities plateaus are formed by No. 3, but more frequently it forms the highest bluffs of narrow ridges. It is divided into two subdivisions, the lower and the upper No. 3. The former can be recognized by its dark color and its more precipitous character, while in the upper, the colors are by far lighter and the steep features less prominent, as it decomposes more readily and therefore forms slopes rather than vertical bluffs. Lithologically there are distinctions also, as will be seen below. No. 3, lower, at times shows columnar structure, and on account of the dark color it assumes upon weathering, can be mistaken for basalt. Brown is the prevailing color of the lower members, while the upper ones are lilac, shading into gray and reddish. For the latter the thickness may be estimated at 1,000 to 1,500 feet, when fully developed; for the former at 800 to 1,000 feet. This formation is well developed at a number of points, and will be spoken of in more detail when treating of the localities where it occurs. These two last numbers mainly give the country that appearance which has induced me to term it a "bluff country," a character which extends from the 107th meridian to San Luis Valley, of course with some interruptions caused by local upheavals or other disturbances.

Numerous sanidite crystals occur in the sometimes compact, sometimes slightly vesicular, paste; more in No. 3, lower, than in the upper subdivision. Mica is found more sparingly, black when fresh, bronze-colored after having been exposed to atmospheric influences for some time. No. 3, upper, contains less sanidite and more mica, and may be distinguished by the lighter color of its paste. Toward the upper portion of this number a series of beds occurs, that have almost the character of a paste without any segregated minerals. In color, they are usually light, compact as a rule, rarely vesicular.

No. 4 is by far more varied in its several members than any one of the preceding series. It is to this group chiefly that the region designated as "mountain country" belongs, and much of the wild, picturesque

scenery it contains is due to the brilliant colors some of the strata belonging to it exhibit. As stated above, the mountains show no arrangement in chains or well-defined systems of ranges, but, in their detail of form, they certainly deserve admiration and attention. At the majority of points, where distinct stratification could be observed in the layers composing No. 4, it was seen to be either horizontal, or very nearly so. This fact, together with the unequal hardness of the various strata, produced the result that erosion finally, after other agents perhaps had completed the primary separation, was enabled to carve with its skillful hand the most unique mountain forms, beautiful in their symmetry as well as in their detail. The colors of this series are generally dark, with the exception of those shown by one stratum—the "*red stratum*." Originally white, the color has changed into yellow, orange, bright red, and brown. A very thorough impregnation of minute pyrite crystals has produced this change. Upon decomposition of the pyrite, hydrated sesquioxide of iron is formed, which in turn imparts, according to the quantities in which it is present, the colors above enumerated. This stratum is found in the lower half of the series. Above it the colors are almost invariably dark, a purplish blue, maroon, and frequently a dark, muddy green. Single bands of lighter rocks occur in the upper members. The thickness of No. 4 is between 3,000 and 4,000 feet, containing a by far greater variety of rocks than any one of the lower groups. Without going into detail, it may be well to give a mineralogical diagnosis of specimens from typical localities.

As a rule oligoclase takes the place of sanidite, and mica is entirely wanting. At some points mica was observed, however, in the lower members. A triclinic feldspar, that may be andesite, occurs associated with the oligoclase in smaller crystals. In some specimens sanidite was found, but it may be regarded as the exception rather than as the rule. The paste is microcrystalline to compact.

Above this series of trachytic beds we find in numerous places such rocks that must be and are considered as younger. Frequently occurring, but showing variations in texture and lithological character at almost every point where it does occur, is the rhyolite. As a rule it may be found superincumbent upon the beds above described, forming caps for some of the highest peaks of the district. As the rocks underlying, the rhyolite shows a well-defined stratification, conformable to that of the older strata. At a number of points its character as such cannot otherwise be determined than by its position and texture, inasmuch as its mineralogical character would scarcely warrant any positive assertions. By the aid of partial or full chemical analysis certainly every doubt can readily be cleared. Near station 10, above 5 miles to the eastward, the most typical occurrence of rhyolite was observed. A deep ravine, bordered on either side by sloping walls several thousand feet in height, contains in its lower portions a quantity of massive basalt reaching upward on the north wall to more than 900 feet above the level of the creek. Resting immediately upon this we find a series of rhyolitic beds segregated into narrow strata. It would seem from the position of these two rocks, which can correctly be recognized at a glance, that the latter was really younger than the former. Analogous cases to this have been found in other portions of the western volcanic regions, but whether they are identical can only be determined by one who has seen a number of them.

Upon investigation it will be observed that the single narrow strata of rhyolite lying upon the basalt dip toward the valley at an angle of 60° to 70°. There is no evidence that the material could have flown down-

ward from the north side, producing the dip by virtue of any such flow. On the contrary, it has come from the west. Traveling westward to the head waters of the small creek (we were camped upon a tributary of Godwin's Creek), it will be seen that with increasing elevation the basalt ceases, and a number of small hills are formed by the rhyolite. In any other direction than westward, only small isolated patches of rhyolite are found, fewer of them toward the east. Considering all these circumstances, the conclusion presents itself that we here have an instance of intrusive basalt, having become intrusive after the flow or flows of rhyolite had already assumed a state of rigidity. In no case within the district besides this one have I found these two rocks in the same relative position. In speaking of the country drained by Lake Fork Creek and its tributaries, I shall have occasion to enter into the detail of the mineralogical character of this and several other interesting rocks found at that locality.

Dolerite and basalt both occur in this district, the latter in by far greater quantities, however, and in a number of varieties. The three plateaus upon which the stations 3, and 4, 5, and 19 and 20 are located, are capped by a heavy layer of basalt. Generally the color is a dark gray or black, but in a number of instances it was found to be a brownish-red, produced by decomposition of the magnetite it contains. These three plateaus strike in one line, approximately north and south, and a former connection between the two more northerly ones seems highly probable. Station 3 has an elevation of 12,669 feet, while station 5, seven miles distant in a straight line, is only 101 feet higher. Both are located on the summit of the plateaus, and their elevation shows that there can have been but very little change in the *niveau* of these beds independent of each other. It has been mentioned above, that the highest members of the trachytic group are to be found in the western part of the district. This is probably owing to the fact that the eastern portions were, at the time of eruption, too high to be reached, a view sustained by the observation just quoted. We find the basalt of these plateaus resting upon trachyte No. 2, except at stations 19 and 20, where it covers No. 3. On the summit of the Rio Grande Pyramid (station 21), we find the same case occurring, a cap of basalt, 600 feet in thickness, forming the highest portion of the peak. Isolated patches of basalt occur at a number of points, forming either the caps of peaks, or presenting, in the lower southerly country, single eruptions of but small extent. Station 18, on the north side of the Rio Grande, east of Pole Creek, shows a cap of this kind. East of station 10, in the narrow cañon, basalt also crops out, underlying the rhyolite. In its specific features it is quite interesting at that locality, and shall be spoken of more at length hereafter. In color it is there almost black, weathering brown on the surface. Small particles of olivine are contained in the microcrystalline paste. Prisms of augite occur sparingly. Altogether the rock has a more crystalline appearance than basalt generally shows. With basalt the list of volcanic rocks found in our district is exhausted, and we shall proceed to give a synopsis of their horizontal distribution according to the various drainage systems.

A line drawn northward from Del Norte on the Rio Grande, to Saguache, would approximately give the eastern border of the volcanic rocks. It is there that the bluffy character is well developed, continuing westward for some distance up the Rio Grande. Mostly of a brown to reddish-brown color, the perpendicular walls, sometimes several hundred feet in height, give to the country a very characteristic aspect. Trachyte No. 2 composes these bluffs, allowing an exposure of No. 1 at

only a few places on the river. The general dip of the flows to which the bluffs owe their existence is a little south of east, amounting from 2 to 5 degrees, except at points where later local disturbances have increased it.

At Wagonwheel Gap a local phenomenon of some interest occurs. The flow of trachytic material became somewhat columnar upon cooling, and afterward a small hill composed of it was torn apart, leaving nearly vertical cliffs on either side. Through this narrow passage the river has found its way, leaving on either side of its banks sufficient space for wagon-roads. Indians have taken advantage of the commanding view obtained from the highest portions of the hill, and numerous abandoned "lookouts" and low walls along the edges testify to their presence in former days. At that locality, as well as several others, the trachyte No. 2 contains numerous fragments of jasper, chalcedony, and flint, sometimes in the form of geodes. Above the gap the same formations continue without any material change in either stratigraphical or orographical features. The valley of the Rio Grande all along there is of considerable width, and the bottom composed of trachytic drift. To the south and southeast the La Plata Mountains rise to considerable elevations, consisting probably of trachytic material also.

Antelope Park, at an elevation of 9,000 feet, presents some interesting features. To the northeast of the park is Bristol Head (station 54), the termination of one of the long, high plateaus running southward from station 2. At its southwest termination this plateau presents a vertical wall over 2,500 feet in height; then proceeding farther in that direction, the Santa Maria lake is reached, while on the other side of it there is an analogous vertical wall, about 1,200 feet in height. The lake is contained in a long narrow valley, partly timbered, partly grassy. At the east end of this valley are the Antelope Springs, so called. Upon examination it will be found that the upper strata of trachytic rocks on the bluff edge upon which the station was located, correspond to those on the other side, although they are more than 1,000 feet lower down. It is a case of sudden subsidence, whereby the portion on the southwestern side changed both its horizontal and vertical position, while Bristol Head remained stationary. To the northeast of the station the strata dip slightly in that direction, while those having fallen, on the other side, dip at an angle of 6° to 10° to the southwest. This dip shows that the subsidence was by no means a perpendicular one, but that the southern side fell more than the opposite. Thanks to the excellent view obtained from Bristol Head, there could not very long remain any doubt as to the action that produced this result. Reaching Antelope Park from the west side, an exposure of the upper members of No. 1 and the lower ones of the succeeding numbers will be observed. Physically they are soft, and rapidly yielding to atmospheric and erosive influences. Opposite that exposure, which is soon hidden from sight by the secondarily acquired position of the "dropped" superincumbent beds, the Rio Grande emerges from a narrow cañon, and closely hugging the rocky banks on the south side of the park, follows them for some distance below San Juan City. The valley comprising the park is slightly rising toward Bristol Head, and in it the old course of the river can easily be traced. It will be found that instead of following closely along the south banks, which are determined by the trachytic bluffs of No. 2, the river from its point of egress formerly flowed across the entire valley, and, winding along in curving lines, kept a course much nearer to Bristol Head than the one it has to-day. It seems

highly probable, therefore, that at some period previous to that at which the river had the course just described, it flowed still more northerly, *i. e.*, at the time before the subsidence occurred. Counting upon the regularity shown at numerous other points by the members of volcanic series, the view may gain ground, supported besides by other facts, that the subsidence mentioned is owing to a washing out of the soft lower strata. As soon as a sufficient distance was thus eroded, the rocks superincumbent changed, by their falling down and southward, the course of the river. An isolation of the narrow valley lying between the two vertical walls thus formed, would be advantageous to the formation of either swamps or lakes, and we do in reality find one of the latter. Its longer axis is parallel to the line of separation of the two vertical bluffs.

Still farther ascending the river we find it running in trachyte No. 2, which forms steep bluffs on either side, and narrows the cañon very considerably at some places. While the elevation of the river-bed is about 9,400 feet along there, the hills on the north side rise to nearly 10,500 feet, reaching trachyte No. 3. Along some of the ridges this rock shows very decidedly columnar structure, resembling from a distance basaltic columns. In color it is dark, and weathers in steep cliffs. After reaching Lost Trail Creek the higher country begins. Both south and north of the Rio Grande mountain-peaks become more frequent and their altitudes more considerable than farther east. On the south side of the river, ascending the main tributaries, we observe the lower numbers two and three in regular succession and typical development. The Rio Grande Pyramid (station 21) is the highest trachytic point in that direction, 13,773 feet. Beyond that and to the westward, the volcanic rocks begin to thin out owing to the position of underlying metamorphics. At the time of the flows, the metamorphic regions must have been sufficiently elevated not to be covered entirely by them. Although, as shown by small local outcrops, quite an extensive area of these rocks is covered by volcanics, the high portions, the Quartzite Mountains, impeded the progress of the eruptive material. Along a line that begins near station 22, and running northwesterly terminates near station 17, the volcanic rocks are overlying the metamorphic rocks, and while the former show nearly horizontal stratification, the latter have a dip of 12° to 18° to the northward. Station 24 is a prominent trachytic point projecting south toward the metamorphic area.

On station 21 a good section of the volcanic rocks was obtained, showing the regular order that has been observed at a number of other localities. The summit is composed of basalt, capping the other rocks, and having a thickness of 600 feet. Below it there are 200 feet of breccia. This breccia is composed of numerous large and small fragments of the underlying strata, and cemented rather loosely by a cement of feldspathic character. Then follow 400 feet of a compact gray rock, without any distinctly segregated minerals. It resembles a feldspathic matrix, without any minerals contained in it, and varies in color from yellowish to gray, and sometimes pink. Between this and the next lower member there occurs a band of porphyritic pitchstone, containing numerous crystals of sanidite, and small decomposing fragments of another feldspar. At the point of observation this interstratum was 8 to 10 feet thick, but as it continues for several miles in an easterly and southerly direction, variations in thickness occur. Below this pitchstone stratum trachyte No. 3 sets in; 400 feet of a light pink to reddish rock compose the upper portion of that number, followed, lower down, by 800 feet of the dark-brown laminated trachyte, with much sanidite

and but little mica. A small quantity of No. 2 is found below this, weathering very readily into small scaly fragments. This rests upon a coarse-grained metamorphic granite, which crops out at a number of points, and is a continuation of that found at station 22. To the westward, about nine miles, the characteristic strata of No. 4 set in, forming a high, flat country, in striking contrast with the adjoining quartzitic region. This continues upward to the headwaters of the Rio Grande. On the north side of the river, a short distance west of Lost Trail Creek, there is an excellent development of No. 1, and Nos. 2 and 3 above it. Very unique bluffs, about 860 feet in height, have the appearance of variegated marls more than that of volcanic deposit. Presenting a very marked stratified appearance, it may be observed that this is due mainly to the accumulation of coloring material (oxygen compounds of iron) in certain horizontal zones. Not far up the river is this outcrop continued, however, as it slightly changes its course and the breadth of its valley. As the dip of the flows or strata at that locality is a southeasterly one, the disappearance of the lower stratum becomes a necessity, from the position at which they are exposed. Only on Pole Creek, about three miles from the Rio Grande, and near the junction of the two, they crop out again, showing, in the former case, fantastic forms and groups that an enthusiastic admirer might readily construe into figures resembling human shapes.

Along the north side of the river, the rocks of No. 2 weather in abrupt bluffs, showing horizontal seams, and irregular inclosures of porphyritic pitchstone, that from a distance have the appearance of cavities. Above them are the layers of No. 3, dipping conformably at an angle of 2° to 4°, overlaid in turn by the conglomerate that was mentioned from the Rio Grande Pyramid. About two miles east of Pole Creek is station 18, with an elevation of 13,656 feet, capped by a prominent cap of black basalt. This feature will make the peak distinguishable from any others in the vicinity. Westward of Pole Creek the character changes; we already begin to reach the section which, in the beginning of this chapter, was termed the mountain region. Mount Canby is the first one that presents the characteristic "red stratum." We have approached that area which was not flooded by the trachytic eruptions simultaneously with the regions farther east, and although only a few miles distant, we find that this peak, at an altitude of about 12,700 feet, shows the lower members of No. 4. Weathering with all the brilliancy that colors originated by ferric oxygen-compounds can produce, it presents, in its variety of shades as well as its elongated pyramidal form, one of the most striking features of the valley. But a short distance northwest of this mountain are the sources of the Rio Grande, which for more than 90 miles flows through one continuous area of volcanic country.

In concluding the consideration of the formations bordering this river and its principal drainage, I wish to say a few words regarding the extraordinary regularity shown both in the mineralogical development and the distribution of the rocks in question. Below the junction of Pole creek, the most regular development may be said to begin. One stratum upon the other is found to be in its normal position, and specimens taken miles apart would readily be mistaken for those of the same numbers occurring at other localities. Although deep ravines and narrow gorges frequently traverse the sides of the long ridges, or even cut them, this result seems to be owing to anything but very destructive activity. At some points, certainly along the Rio Grande, the view can hardly be repelled that the cañons must have been formed by a sep-

aration of their two present walls, a separation that was not gradual, such as would be produced by the erosive action of flowing waters, but a sudden one. From Lost Trail Creek eastward the lower members of the trachytic system can be readily traced for many miles. The dip is constant in the direction the river flows, but slight. If time could be spared for a careful investigation of the volcanic rocks along the Rio Grande much valuable information regarding their horizontal and vertical distribution could be obtained. The extent of the single flows, characterized as such by their stratigraphical relations and lithological character, is truly astonishing, and basing upon this and other evidence, I have come to the conclusion that the volcanic area surveyed by our party in 1873 is but the continuation of the one under mention at present.

Flowing in a northerly direction is White Earth Creek, which has received its name from the exposure of trachyte No. 1. Ascending from station 6 the cañon is found to be walled in by vertical or nearly vertical bluffs of No. 2, while metamorphic rocks crop out below. As usual, they present the rugged appearance common to members of that number, until the small valley north of station 2 is reached, where the flows have preserved more of their original form, and show plateaus of no very considerable extent, however. Above the first lower plateau two more are found, until finally a slope is reached leading up to the station, an elevation of 13,560 feet. Here the rock corresponds to some of the members of the higher No. 3. The paste of this rock is compact, darker than that of the corresponding group generally. Numerous crystals of yellowish sanidite occur in it, while mica is wanting almost entirely.

Descending again to the level of the creek, it is found that the strata of No. 1 crop out for some distance along its left-hand bank. The rock here is white to grayish and yellowish, readily decomposed. It is not so firm in texture as that on the Rio Grande, and therefore does not show the picturesque forms that were observed at that point. Higher up the succeeding numbers set in until No. 3 is reached. At all these localities the bluff character is well preserved. At many places the rocks are bare of any vegetation or soil, and the traveler rides over the surface, as it formerly flowed, only with the difference that at present it shows an easterly dip. Ascending still farther, toward stations 3 and 4, basalt sets in about 400 feet in thickness at the edges of the continous bluff. A long, high plateau, some distance above timber-line, stretches from north to south approximately. No soil has accumulated as yet on the naked fragments of vesicular basalt. Numerous little ponds and swamps indicate that beneath the layer of fragments, the original flow must be undisturbed. Two varieties of basalt occur here, the black and a brownish-red. No definite relation between the two could be recognized, and it seems highly improbable that it should exist. Both are vesicular, sometimes having the vesicles drawn out to one or two inches in length. Olivine, a dark-green variety, is found sparingly in their microcrystalline paste. Indications of columnar structure may be observed along the precipitous bluff on the west and southwest sides, but the columns are not well developed. Station 5, at an elevation of 12,737 feet, is located a little west of south of the two last-named stations, on a similar plateau, which at one time was probably in connection with it.

These plateaus separate the waters of White Earth from those of Lake Fork Creek. Near the northern line of our district, between the two last-named creeks, station 7 was located on an isolated patch of

basalt, surrounded on all sides by granite. A short distance southward, however, the volcanic area again began. Ascending Lake Fork the two lower members of the trachytic series are met with. Opposite station 11 (10,611 feet), No. 1 has reached a good development. For 800 feet we find a series of grayish, pinkish, to red trachytes, weathering in small fragments. Sanidite and hornblende are abundant in it; more particularly the latter. Near the base of station 11 erratic granitic bowlders were observed; not in great quantity, however. It is a coarse-grained granite, of the first type that is described from the metamorphic region. Subsequently discovered outcrops of this same granite, a short distance from station 12, disclosed the origin of the bowlders. About four miles south of station 11 is San Cristoval Lake, above which the erratic metamorphic material is found in greater abundance than farther below. The bowlders are larger, intermixed in the bed of the creek with numerous small ones and pebbles. Although no distinct evidences of glacial action were found either on the bottom of the narrow valley, or along the steep walls inclosing it, I am inclined to think that such action must have produced the result observed. The valley is a comparatively straight one up to the point where the granite comes to the surface, and its form is that of a trough. Near the last large bend, east of station 12, some of the granitic rocks, *in positu*, show a very smooth surface. Inasmuch as the physical character of that granite admits of weathering that would produce the same effect, I am, therefore, not prepared to assert the existence of a glacier of large extent at any former time, but it becomes a matter of great difficulty to account for the existence of the erratic material at the localities where it was observed unless that view be held.

An interesting feature was observed at the north end of San Cristoval Lake. From the east a rapid mountain-stream flows down into Lake Fork, near the junction of which a large mass of yellow volcanic material has been deposited. This material was not deposited by any volcanic activity, however, but was brought down from the eastern mountain-ridge through the channel of the present creek. It seems improbable that so large a mass should have been carried there by the comparatively small quantity of water, so that very likely snow-slides or even glacial action may have contributed their share. By the means of this body of soil and undecomposed volcanic material having been lodged immediately in the course of Lake Fork, that creek was dammed back, and the present lake was formed. It seems probable that all, or at least a very large percentage of it, must have been transported to the place at once, otherwise the main creek would have been able, gradually, to cut its way through, and the formation of the lake would thus have been prevented. Judging from the "fresh" character of the surface, it would seem as if this enormous land-slide had occurred but a comparatively short time ago. Small islands in the lake, only a few yards long, with fir-trees growing upon them, speak for the same view.

As mentioned above, a small amount of metamorphic granite crops out near the last large turn of Lake Fork, overlaid by trachyte. Station 12 was located on No. 4, at an elevation of 13,967 feet, the last prominent point of a ridge running from north to south. This ridge is remarkable for its beautiful detail form, and for the excellent development of the "red stratum." We have again reached the region of high mountains, and with it the higher trachytic strata. Ascending still farther up the creek, we soon leave the lower members of the series altogether and are in No. 4. One of the most prominent points near the headwaters of Lake Fork is Handie's peak, 13,997 feet high. Here the

strata of No. 4 are particularly well developed, and afford important information as to vertical succession. As a rule, the paste is of dark color, a bluish to maroon, sometimes with a greenish tinge, while the feldspars contained in it are yellowish. Small crystalline fragments of feldspar are frequent in the higher strata of this peak, and it is they that usually impart the greenish color to the rock. They receive their color in turn from a small percentage of protoxide of iron. Near the summit is a band of whitish rock, about 200 feet in thickness, that appears like a matrix, without any segregated minerals.

Descending from Handie's Peak we pass over an outcrop of metamorphic granite, in the short but deep cañon leading down to the main creek, and there again reach volcanic rocks. Above this point we ascend rapidly until the pass is reached, leading over to the Animas Forks. With that the region of ore-bearing rocks begins, and that will be treated of in the chapter upon the San Juan mines.

One of the main tributaries of Lake Fork is Godwin's Creek, the junction of which is opposite station 11. This creek drains a very high and interesting section of country. Single prominent peaks of considerable altitude are contained in it, and the remainder, partly grassy plateaus, partly small ridges, is to a great extent above timber-line. Station 8 is located at an elevation of 12,959 feet, on trachyte No. 3, and from there a good view of Uncompahgre peak, the highest mountain of the region, was obtained. On the station mentioned, the volcanic strata or flows dip off to the eastward, inclining slightly to the north. The rock composing the summit of the occupied point is very hard, has a dark paste, but weathers brown. Crystals of sanidite occur throughout. Hyalite may be found in small cavities or fissures.

Ascending farther up the creek, one of the most important localities of our district was reached, that about 5 miles east of station 10, at camp 23. While all other points thus far visited had failed to offer any explanation as to the locality from which the enormous quantities of volcanic material flowed, the point just mentioned afforded sufficient evidence regarding that interesting question. Near camp 23, as has been mentioned above, the only place was found where basalt occurred in a comparatively low country (10,679 feet), and it was there where rhyolite was observed to cover it. From the creek upward, on the north side, steep, dark-colored bluffs rose, cut into many irregularly-shaped fragments by erosion. Above them a light-colored mass of rocks appeared, showing separation into distinct narrow strata, inclining at an angle that reached 60° to 70°. The former is basalt, the latter rhyolite. Of compact microcrystalline texture, the basalt showed numerous inclosures of epigene minerals, chalcedony, agate, amethyst, stilbite, and calcite. The three former occurred in small, perfectly-filled geodes, while the two latter were generally found in fissures and cracks. Immediately upon this rock lay the rhyolite, in the stated position. A white to grayish paste, very compact, contains numerous small crystals of transparent quartz with double terminations. Crystals of sanidite are dispersed throughout the entire mass, and small six-sided prisms of black mica occur sparingly. Near the junction of the rhyolite with basalt, a curious interstratum was found, only 6″ to 8″ in thickness. It is a brown, vitreous pitchstone, containing crystals of quartz and sanidite but no mica. This stratum was only traced for a short distance, owing to the precipitous character of the walls, but probably extends for some distance, analogous to the occurrences at other points. Farther up the valley rhyolitic hills appear, light-gray to white in color. Ascending the basaltic wall for about 700 feet, the

rhyolite is reached, and, receding toward the higher portions of the region, extends for a vertical distance of 200 feet. After this a nearly level area is traversed, while the ascent for the distance may amount to 100 feet. Above this, however, the trachytic beds are found in their regular succession, at first the upper portions of No. 3, then the lower ones of No. 4. It is evident, therefore, that from this side no flow of rhyolites could have occurred, and from any other side the possibility is precluded by the geognostic features of the surroundings. It is my opinion, therefore, that the rhyolite occupied at one time a position very near the base of the valley, and the outflowing basalt caused it to assume that in which it is found at present. Inasmuch as this was the only locality where we had occasion to observe two of the youngest volcanic eruptive rocks together, my attention was led to the question whether this might not be regarded as one of the greatest points of outflow, if not as the only one. Subsequent evidence, derived from the stratification of the flows, confirmed this opinion, and I have arrived at the conclusion that near this point the main outflow for the entire continuous volcanic area under consideration occurred. In speaking of the stratification of the volcanic rocks this point shall be further elucidated.

Near one of two tributaries of Godwin Creek is Uncompahgre peak (station 9?, 14,235 feet above sea-level. The summit of this mountain is formed by No. 3, and the lowest portions by No. 2. At the higher portions of the peak the strata dip from 3° to 6° to the northeast, away from the rhyolitic region that has just been described. The mountain presents a bold appearance, and serves as a landmark for many miles. Toward the southwest and west it slopes off more gently than toward any other, but to the northeast presents a very steep appearance. A small peak, to the southwest of Uncompahgre, shows the identical strata, lower, however, in elevation, and dipping in immediately the opposite direction, to the southwest. This fact is of importance, as this peak is nearer to the center of eruption. A number of high points are found in the vicinity of Uncompahgre, none, however, reaching the same altitude. Many of them present the same stratigraphical relations.

Flowing in a northerly direction, west of Lake Fork, is Uncompahgre River, rising near station 28. At that locality the strata of No. 4 have reached a very good development, and in the ridge containing stations 27 and 28 the red stratum is particularly conspicuous. About four miles north of station 28, station 29 is located, on the characteristic bluish trachytes of No. 4, resembling closely those forming the higher portions of Handie's peak. Similar to the occurrence of the white band near the summit of that peak, we find one here of almost identical composition and location. The trachytic rocks weather in scaly fragments, sometimes of considerable size but of small thickness. From that point the higher numbers of trachyte extend northward in narrow ridges, but little cut by lateral drainage. A tendency to columnar structure produces along the steep sides of these elongated ridges numerous pinnacles, from a distance apparently small. They reach considerable vertical dimensions, however, and may be compared to the ornamental spires of Gothic architecture. Added to the effect produced by their form, the colors they exhibit are an additional factor. Near the headwaters of some of the Uncompahgre's tributaries is one peak that attracted attention by its singularly regular form, long before it was reached—Mount Sneffels, reaching an altitude of 14,162 feet. It was our station 33, and proved to be an interesting point. Horizontally stratified, or with an imperceptible dip of the strata, this mountain towers far above its surroundings, rising more than 7,000 feet from the lower country

to the west. While the higher portions of the peak are composed of trachyte No. 4, the last 400 feet proved to be rhyolitic material. Differing from the typical rhyolite, its structure and composition, nevertheless, assign this place to it. On the fresh break the rock has a muddy olive-green color, but turns brown upon exposure. Its structure is somewhat crystalline, owing to the large quantity of feldspathic crystals contained in the paste. To the southwest of Mount Sneffels a very extensive "drop" of the volcanic strata occurred, about four miles in length, and a little more than a mile in width. Unlike the one described from Bristol Head, no erosive agent can have occasioned this one, as there is no connection between the sunken area and any point from whence such an agent could have operated. The strata have dropped down perpendicularly for more than 2,000 feet, retaining to some extent among the mass of *débris* their original connection. Approaching from the south or southwest, the ridge suddenly falls off in vertical bluffs, and only the accumulated mass of broken fragments enables the descent. We have named this place the "Great Amphitheater," as it resembles one in shape. Those strata, that show a partial connection, are cracked in every direction, traversed by large and small fissures. Masses of broken rocks are constantly rolling down the steep sides into the depression, so that in course of time much of the present grand aspect of the peculiar formation will be lost. The ridge extending westward from Mount Sneffels drops off into the sedimentary bluff country, remaining volcanic throughout its entire length. As at numerous other points near the edge of the volcanic area, so the mountains here, too, show a regular stratification, almost horizontal. It seems highly probable that subsequent erosion, to a great extent, determined their present forms, as it appears incredible that flows of such considerable vertical dimensions should terminate so abruptly. Evidence was obtained at several places near this ridge and those adjoining that the sedimentary beds held, at the time of the eruptive flows, the same position they now occupy. They belong to the Cretaceous system.

The San Miguel River rises in volcanic country, but soon leaves it, and flows through sedimentary formations. There, as well as near the headwaters of the Rio Dolores, the trachytes show the same character as along the ridges upon which station 24 was located. Besides these two streams the Rio Animas heads in a portion of the high volcanic district, as well as its northerly tributaries. In the chapter on the mines of the San Juan region the character of the rocks through which the Upper Animas flows will be discussed, and for this place, therefore, only some of its tributaries remain to be described. Bear Creek, heading near station 30, flows in an easterly direction and joins the Animas in Baker's Park, near Silverton. Ascending that creek from the park mentioned, the red stratum may be observed following along Mineral Creek, which branches off to the northward from Bear Creek. The former rises near station 28, where the red stratum is very well developed. Soon, however, after traveling up Bear Creek beyond the junction with Mineral, sedimentary beds set in, overlaid by the trachyte. Station 30 is located on the highest point of the ridge separating the waters of the Animas from those of the San Miguel. Its elevation is 13,897 feet. On either side of the ridge sedimentary beds appear, and the volcanic rocks only form the capping of the ridges or isolated peaks. A considerable amount of metamorphosis of the sedimentary beds has been produced by the action of the overflowing volcanic material. The summit of station 30 is formed by a very peculiar rock. A microcrys-

FIG. 2.—LIZARD'S HEAD.

talline paste contains innumerable small crystals of epidote, replacing hornblende. At some places the epidote congregates so as to form narrow veins through the rock. Octahedra of magnetite are also found in the paste, which has a dull gray color. Sanidite occurs only on very minute crystals. Mica was not found at all.

Of interest the ridge running south of Bear Creek from station 30 to Sultan Mountain will be found. Although no sedimentaries appear in Baker's Park, immediately across the ridge they set in, covered by trachytes. Their elevation is quite considerable, reaching more than 10,000 feet at those points. During some former time they were disturbed, and now the trachytes rest unconformably upon them. Sultan Mountain, station 26, is the last massive peak of volcanic material on the downward course of the Animas, and reaches an elevation of 13,366 feet. To the south and southwest the trachytic material shows regular stratification, very nearly horizontal, showing only a slight dip southward. At several points the process of erosion has separated small patches from the main body of volcanic material. This is the case at Engineer Mountain (station 31, 12,971 feet high). A little more than one thousand feet of light-gray trachyte caps the dark-colored Carboniferous sandstone. The shape of the mountain is that of an elongated pyramid, with two very steep sides, the one of them nearly vertical. On the latter side the trachyte shows a decidedly columnar structure, which contrasts sharply with the stratification of the sandstones below. Lithologically the rock belongs to No. 4. It is a light-gray crystalline paste, containing crystals of oligoclase dispersed through the material. Upon weathering, the feldspar decomposes and falls out, giving it a vesicular appearance. Small particles of mica are distributed sparingly. West of Engineer Mountain a sharp ridge extends from north to south, again showing the capping of trachyte upon sedimentary beds. With this the consideration of the continuous area of volcanic material may be regarded as completed, but there are several isolated eruptions occurring in the district surveyed. One of the largest and most prominent is the Mount Wilson group (station 35), of which the highest peak reaches an elevation of 14,280 feet. Immediately northeast of this mountain is the probable point of outflow, spreading from there to the east more particularly. Two of the highest spurs running from the main mass are formed by the flows from Mount Wilson, and rest upon sedimentary strata. Lithologically the trachyte of these spurs would be referred to No. 3. East of the main peak is a curious monument of trachyte, an obelisk-like mass of stone placed upon a natural pedestal, of symmetrical form. The formation of this monument, which was named "Lizard's Head," is owing chiefly to the tendency to columnar structure shown by the rocks. Its height amounts to 290 feet, while at the base its diameter is scarcely over 60 feet. Its summit is 13,160 feet above sea-level. Toward the outer edges of the group the trachytic material is stratified, while on the highest point, Mount Wilson no definite stratification can be observed. On the summit a rock occurs that may be referred to the Doleritic group. The rock is dark-gray to black, containing a feldspar that very closely resembles labradorite. Small nodules occur in it that seem to be composed of minute hornblende crystals, varying somewhat in color.

Another isolated group is the one upon which station 36 is located. On the south side of the Rio Dolores a quantity of volcanic material is found, forming in shape a figure similar to that of the horseshoe. Station 36 is one of the high points of that flow or series of flows, having an elevation of 12,554 feet. From that, and probably two other points

more to the westward, the eruptive rocks spread over the highest portions of two parallel spurs, connected by a third one. Similar to the rocks of neighboring localities we find the lithological character of those found here. The main portion rests upon Carboniferous sandstone, while the two disconnected ends of the horseshoe have flown over Lower Cretaceous rocks. As is usually the case at the points of outflow, the rocks from different altitudes vary considerably in their mineralogical composition. Near the summit of station 36 the rock presents a very handsome appearance. A greenish crystalline paste contains innumerable white crystals of oligoclase, which are set off to advantage by accompanying black crystals of hornblende. Sanidite also occurs. Six hundred feet below the summit the rock is very similar to that described from station 31; a white to light-gray paste, inclosing crystals of oligoclase; mica occurring very sparingly. To the southwest of station 36 is station 37, located upon the above-mentioned red sandstone, but having on either side, north and south, isolated patches of trachytic rocks.. Considerable disturbances have taken place at that locality at one time, prior certainly to the eruption of the volcanics, but it seems that their appearance gave rise to new dislocations, and finally a third era occurred, which was again marked by displacements. South of station 37 a series of sandstone strata that had formerly been forced from their normal position, were still more disturbed by the intrusion of the volcanic mass. Between these strata of sandstone, layers of about equal thickness of trachyte are wedged in, forming apparently a portion of the stratified series. (See section.) A secondary dislocation of about 60 feet vertical distance, has brought the layers of trachyte immediately opposite those of the sandstone, and the reverse.

The La Plata group, at the head of Junction Creek, a tributary of the Animas, is also one of the isolated volcanic regions. Several small patches are adjacent to the mountains, covering either Carboniferous sandstone, or, as was the case at station 42, Lower Cretaceous sandstone. During the following season, 1875, this region will be explored thoroughly, and more light will be thrown upon the specific characters of the La Plata Mountains.

With this latter locality the volcanic area of the district surveyed during 1874 is concluded. Small cones, of basalt probably, were visible from a distance in the Cretaceous country, but were not reached in the course of our travels. There remains now, yet to be considered, the volcanic area as a whole, and the conclusions that may be drawn from the consideration of the stratigraphical conditions of the rocks.

It will be observed that at all points near the border of the volcanic area the strata or flows show a surprising regularity in their structure. Scarcely ever does the dip exceed 2° or at most 3°, unless some very local disturbances have given occasion to an increase thereof. As we approach, however, from the outside of this area toward the interior portions, a marked change in the stratigraphical relations can be observed. We find that the high plateaus, the long-continuing bluffs, and the stratoid peaks, all show a tendency to dip off from one point, as from the center of a circle toward its periphery. With this tendency the dip increases gradually, as we approach that region near which station 10 is located. So far as could be observed, the flows show a dip off from that locality on every side of it, except in the immediate neighborhood, where a number of dips are noticed, falling in toward the depression east of station 10. This feature is so constant, is, furthermore, unique throughout the entire district of which this chapter treats, that I could not do otherwise than attach great importance to it. Taking

into consideration primarily the stratigraphical relations as above given, the conclusion will present itself that this point, or very near this point, must have been the main region of outflow; that here is the center from which the greater portion of the volcanic material spread over the surrounding country. In support of this view are the additional facts that, at the locality in question, rhyolite and basalt, two of the youngest volcanic rocks of that region, were found in a cañon in considerable masses, while at all other points they occupied either the summits of peaks or of extensive plateaus. It seems strange, however, that these same rocks found here, should occur elsewhere at such considerable altitudes. Taking the evidence derived from stratigraphical conditions it would seem that, after the flow of volcanic matter had subsided, a depression of the place from where it was issued took place.

Another point of great interest and importance is that touching the conditions of the country at the time of the outflow. It was observed throughout, that in the eastern portion of the district the lower numbers of the trachyte prevailed, to the absolute exclusion of the highest ones, while in the western localities this order of things was reversed. Inasmuch as the four adopted subdivisions are found occurring conformably, one upon the other, the view that they must have originated from one point, receives a decided support. Should this be the case, then, the facts illustrated by the horizontal distribution of the volcanic material can best be explained by the assumption that during the period of the earlier flows the western country was too high to be invaded, while during the later flows the order of things was reversed, and the eastern portion received none of the younger material. At the time of the succession of flows, the region east of station 10 must have had a by far greater elevation than at present, a fact which is demonstrated by the occurrence of the youngest volcanic rocks at higher altitudes. It would be extremely difficult to attempt a thorough analysis of the dynamics involved in these grand demonstrations of volcanic activity, and particularly so after a survey that has been so limited in time as ours.

CHAPTER III.

SEDIMENTARY AREA.

After leaving the area covered by volcanic rocks, and traveling in a southerly direction, the difference of geological formations can at once be recognized from the configuration of the country. Instead of high, rugged mountains, arranged in groups, without any reference to chain or range systems, we here find a series of approximately parallel ridges, tapering off gradually to the southern plains. While a great portion of the volcanic district reaches above timber-line, the mountains or hills of the sedimentary region are timbered, and the valleys between the ridges show fertile, grassy soil. Although the variation in the lithological formations is not very considerable, it can, nevertheless, be readily recognized from the orographic features of the country. Bordering immediately upon the southern and western edges of the metamorphic area the sedimentary beds begin, extending from there south and westward, with only small interruptions in the latter direction, caused by local volcanic eruptions.

As stated in the chapter on metamorphics, the lowest members of the geological series have almost entirely disappeared, leaving only small remnants that cannot even be positively referred to any definite group. A portion of the Devonian rocks have escaped the influence that metamorphosed underlying beds, and offer an interesting field for study, partly on account of their contact with the metamorphosed material, partly on account of local features they exhibit. Above them the Carboniferous formation sets in, greatly varied in its several members, and retaining characteristic variations over a comparatively large area. After this has been passed, a gap occurs in the adopted succession of geological formations. The Triassic and Jurassic beds are wanting in our district. Immediately above the Carboniferous the Cretaceous strata are found, as it would seem from some exposures, resting unconformably upon the former. These continue for a considerable distance down into the plains, so far as our survey was extended, without being succeeded by Tertiary deposits.

SILURIAN.

Only at one point a series of strata was found to crop out that might be referred to this formation. Although no fossils were observed, and the underlying formations had been thoroughly metamorphosed, the overlying Devonian beds determine the view that they can be placed as belonging to this formation. To the southwest of station 38, in the cañon through which Lime Creek finds its way, a succession of sandstone strata were passed, to which the above remarks refer. It is a white, coarse-grained sandstone, deposited in thick strata, that dip at an angle of about ten degrees to the southward at the point where they were seen. Owing to the densely-wooded character of that portion of the district, no satisfactory data could be obtained regarding the dip at other points. This sandstone, which was observed at no other locality

throughout the entire district, has probably furnished a large portion of the material to which the quartzites of that region owe their existence. Lithologically it is so characteristic that an outcrop at any other place must necessarily have been identified with it; and it is to be hoped that the explorations during the summer of 1875, during which time the eastern limits of the metamorphic area can be studied more in detail, will throw additional light upon its position in the geological scale.

DEVONIAN.

Of by far greater importance than the preceding isolated outcrop is the area covered by Devonian strata. One feature adds greatly to the interest of this group. It is the fact that at some points more extensive deposits, in a vertical direction, are found than at others, both, however, resting directly upon the metamorphic rocks. In character, both lithological and paleontological, the beds, although considerable distances apart, agree very well.

Upon reaching the summit of the pass that leads from Baker's Park into the lower valley of the Animas, a light-blue to grayish limestone is observed, *in positu*, dipping to the northward. It is very similar to, if not identical with, the limited outcrop at the head of Cunningham Gulch, where it rests upon the shistose rock, and is covered by trachyte. This limestone formation continues along the edge of the mountains, descending into the cañon and keeping a course of outcrop approximately parallel to that of the Animas. Section II, given in the discussion of the *Carboniferous*, will show the position of the limestone with reference to overlying and underlying strata. Weathering in steep bluffs, of no very considerable height, however, this rock presents a striking appearance all along the regions of Lime Creek down to the junction of the latter with Cascade Creek. *Rhynchonella*, *Spirifer*, and numerous remains of *Crinoids* that are found at almost every point of exposure facilitate the identification. For the entire series of strata at that locality, a thickness of 1,200 to 1,500 feet may be given. This, as will be seen below, is by far more than the thickness of parallel beds at any other point. But little variation in the lithological and stratigraphical conditions takes place. Above the limestones the Carboniferous beds begin, while they are underlaid, probably for a considerable distance, by the Silurian sandstone. This was observed, however, only at one point. It seems that the metamorphosing agent, that thoroughly changed a large portion of the Devonian strata farther south, either did not reach to the region that has just been discussed, or that an abundance of material underlying the Devonian rocks was sufficient to exhaust its force.

A second outcrop belonging to this formation occurs immediately on the southern boundary of the metamorphic area, running in a northwesterly direction from station 48. This station is located on an isolated patch of Devonian limestone, surrounded on all sides by metamorphic granite. Resting immediately upon this granite, which showed a very marked stratification, conformable with that of the superincumbent sedimentary beds, a white to red and brown quartzite was found. At some points the contact of the latter with the granite was so intimate that specimens could be obtained, showing both the granular quartzite and the coarse-grained granite on the same piece. No definite relation of the colors exhibited by the quartzite could be established, save the general rule that the nearer it was to the underlying metamorphic rock, the more intensely it was colored. Proceeding in a south-

westerly direction from station 48, granite is crossed, and a short distance beyond the same stratum is found, bearing the same relations to over and under lying formations. It is evident, from the stratigraphical character of the granite, and from the position it occupies with reference to the sedimentary beds, that at the place to which these remarks apply, it was formed from sedimentary deposits that have now disappeared. Above the quartzite is a thin stratum of yellow siliceous shales, containing narrow interstrata of softer shales. In these the well-known and characteristic pseudomorphs after salt were found. During the formation of the Devonian beach that now remains quartzite and quartzitic shales, portions of the water, that even at so early a geological period contained sodium-chloride, were separated from the main body. Upon evaporation the mineral constituents of the water crystallized. Subsequent inundations of the places that had scarcely been laid dry, brought with them sand and silt, covering the newly-formed crystals. By the gradual percolation of water through the cover the salt was dissolved, and a quantity of the material composing the cover found its way into the cavities thus produced. It will be noticed, therefore, that whenever these pseudomorphs of sand after salt are found *in positu*, the crystals will be observed on the *lower* side of stratum containing them. Occurrences of this kind are not unfrequent in younger formations both of this country and Europe. Besides these pseudomorphs, scales and fragments of bones are found, belonging to some fish of considerable size. Too little material could be collected to admit of any identification, even only generically. Small scutellæ also occur, probably belonging to the same animal. This stratum, as well as the quartzite underlying it, can be traced on the southern side of the granite strip.

Above this the limestones set in. On station 48 it presented a very curious appearance. In every direction the isolated stratum is traversed by vertical fissures, sometimes 8 to 10 feet in width, sometimes only a few inches. Throughout the entire mass innumerable small cracks occur, so thoroughly breaking up the limestones that it was a difficult matter to obtain even small fossils that were not already broken. The whole phenomenon was that of the result of a vertical force acting with limited lateral pressure. I ascribe it to the same cause that produced the metamorphosis of the underlying strata. As in the two preceding cases, this limestone also continues farther south, forming an abrupt bluff toward the northeast and east. The continuation shows more strata than were observed on station 48, but the horizon for fossils remains the same. Here the evidence of decomposing and disturbing influences is not so thoroughly marked, although it can readily be noticed. Thousands of fossils were found on station 48 belonging to a few species only, but nearly all of them in a very poor state of preservation, owing to the causes above given. At some places the limestone was almost entirely composed of the remains of *Brachiopods*, while at others they were distributed more sparingly. This stratum seems to me to mark the upper limit of the Devonian formation in that section of country, and, although no very decisive paleontological evidence can be adduced for assigning the overlying beds to the Carboniferous, it must be remembered how very closely the organic remains of the Upper Devonian and Lower Carboniferous are related to each other in our western groups belonging to those formations. A number of species were found in the limestone of station 48 and its continuation southward, which Professor F. B. Meek has kindly identified. He describes, from the material submitted to him, a new species,* the description of which is given below.

* Bulletin United States Geological and Geographical Survey, second series, No. 1, 1875, page 46.

A small *Productus* was found, resembling *P. subaculeatus;* occurs sparingly. *Orthoceras* is found, but in a very poor state of preservation. *Athyris* and *Rhynchonella* occur. *Bellerophon* and *Euomphalus* were collected in imperfect specimens.

By far the most numerous and varied species occurring there is the one described by Professor Meek as—

RHYNCHONELLA ENDLICHI, Meek.

Shell attaining a rather large size, subtrigonal, with breadth nearly or quite equaling the length, the widest part being in advance of the middle, becoming very convex with age anteriorly; posterior lateral margins straight, or but slightly convex in outline, laterally compressed or flattened, and diverging from the beaks, in adult specimens, usually at about right angles or less; anterior lateral margins rounding to the front, which is generally more or less produced, and, as seen in a direct view from above or below, transversely truncated or a little sinuous at the middle. Dorsal valve very convex, particularly along the middle, the elevation increasing rapidly to the front, which is raised so as to form a very prominent, broad, rounded, or somewhat flattened, and slightly-defined mesial fold, rarely traceable back to the central region, while, on each side, the lateral slopes descend abruptly to connect with those of the other valve; beak moderately prominent, and incurved more or less nearly at right angles to general plane of the valves; interior with a prominent mesial septum extending forward nearly half way to the front. Ventral valve flattened at the umbo, and so broadly and profoundly sinuous from near the same anteriorly as to leave only a prominent angular margin on each side, the sinus being broadly flattened along the middle, and increasing rapidly in depth to the front margin, which is curved upward more or less nearly at right angles to the plane of the valves, and produced in the middle, in the form of a large extension fitting into a corresponding sinuosity in the middle of the front of the other valve; anterior lateral margins on each side of the sinus meeting those of the other valve at acute angles; posterior lateral margins very abruptly deflected and rectangularly deflected along each side of the sinus, to meet those of the other valve; beak comparatively small. Surface of both valves ornamented by numerous radiating costæ, which, on the umbones, are merely distinct raised lines, but increase in size anteriorly, particularly those in the sinus and on the mesial fold, where, toward the front of adult specimens, they become moderate-sized, rounded ribs, of which four to six or seven may be counted in the immediate flattened bottom of the sinus, and two or three more on the fold, while those on the lateral slopes bifurcate, and continue, of smaller size, to the anterior and antero-lateral margins. (Finer surface-markings unknown).

Length of an adult specimen, 1.78 inches; breadth, 1.53 inches; convexity, about 1.24 inches.

This is a fine species, more nearly resembling some Devonian and Upper Silurian forms than the usual Carboniferous types. Its most marked features are the large size of its mesial sinus, the flattening of its posterior lateral slopes, and the angularity of the posterior lateral margins of its ventral valve on each side of the sinus, formed by the abrupt flexure of those margins to meet those of the other valve. This inflection of the posterior lateral margins gives this part of the shell a peculiar truncated, rectangular appearance, contrasting strongly with the very acute angles formed by the connection of the antero-lateral margins of the valve.

The specific name is given in honor of Dr. Endlich, of the United States geological survey of the Territories.

Location and position.—East of Animas River, Colorado Territory, where it occurs associated with a small *Productus* of the type of *P. subaculeatus.* According to Dr. Endlich's sections, as well as from its affinities, it would seem to be most properly of an Upper Devonian species. Fragments of it have been brought in from other localities in the Rocky Mountains.

As mentioned before, the Devonian strata extend from station 48 in a northwesterly direction, reaching nearly to the edge of a cañon that separates the main mass of the Quartzite Mountains from the sedimentary area. A number of points along this line of outcrop are the highest on the sedimentary ridges. True to the general character of the stratigraphy of that region, the beds dip off to the south and southwest, at an angle varying from two to six degrees. So far as could be determined, the strata show very nearly the same condition in the other portions of the Devonian area, as they were described from station 48.

A section taken from station 48 to station 49 (section I,) which is located on Lower Carboniferous strata, will show the relations of the sedimentary beds to the underlying metamorphics. Under the granite a shistose rock sets in, *a*, that is merely a continuation of the large masses occurring near the borders of the quartzites. Above it follows the stratoid granite *b*, dipping off to the south and southwest conformably with the overlying beds. The quartzite sets in then and continues to the southward, *c*. Ascending higher, we reach the siliceous shales, *d*, containing the pseudomorphs of salt and the remains of fish. Blue limestone, *e*, forms the capping of the small plateau upon which station 48 is located, and, as well as the rest, continues southward, growing thicker, however. Above this the Carboniferous beds set in. The entire thickness of the sedimentaries at station 48 amounts to about two hundred feet, while farther south the limestone, *e*, alone reaches that figure. Horizons for fossils, that were observed along the bluffs south of station 48, let it appear that the stratum covering that point must have been either eroded or must have disappeared in consequence of the activity that produced the metamorphic rocks. Comparing the thicknesses we find here with those observed on Lime Creek, the striking difference will be observed at once. A very large portion of the Devonian strata has been converted into coarse-grained granite near station 48. I see no reason to assume that the deposition at that point was less in thickness than twenty miles farther to the northwest. These two localities exhaust the outcrops of Devonian rocks in our district. Their relations to overlying formations are very simple, having a conformable stratification.

CARBONIFEROUS.

Members belonging to this formation cover a great deal more ground than those of the preceding group. It is mainly divided into two divisions, the Lower Carboniferous, and the Upper, containing the red sandstone. The former crops out all along the west side of the Animas, down to about the middle of Animas Park, while on the east side of the Animas it forms a part of the higher ridges sloping off southward from the Devonian area of that region. Throughout the area which it covers, its stratigraphical relations conform entirely to those of the underlying Devonian rocks. Varied as the formation is, and notwithstanding its quite considerable vertical development, but few localities were found where characteristic fossils afforded any definite evidence regarding age. The

Section I.

Station 49

b a f e d c

d c

Station 48

a

stratified

Section running from Station 48
through Station 49.— 15 Miles.

absence of fossils was particularly noticeable in the upper division, in the red sandstones. With their aid, *i. e.*, with the aid of typical forms, any lingering doubt regarding their age could have been cleared satisfactorily. As it is, only a few organic remains were found, and it becomes necessary to employ stratigraphical evidence in support of any view that may be entertained with regard to their age.

While the lower division of the Carboniferous is composed of a series of beds, containing sandstones, shales, and limestones, the upper is confined almost entirely to the massive beds of red sandstone. In its lower strata the former shows mainly yellowish sandstones, interstratified with yellowish and gray shales, while, higher up, the blue limestones set in, containing characteristic fossils. Immediately above that the red sandstones begin, and continue in an unbroken series until the white sandstones of the Lower Cretaceous are reached. Trias and Jura are missing or reduced to a minimum and only exposed locally. Of one feature mention may be made, that had a great influence upon the subsequent configuration of the country and determination of the drainage. In the chapter on metamorphics an anticlinal axis has been alluded to, running through a large portion of the sedimentary formations, and continuing from there eastward through the Quartzite Mountains. So far as our work extended westward the traces of this disturbance could be observed. The line it pursues is approximately from west to east, with a number of small curves. A short distance west of station 37 it was first noticed, running a little northward past that station; it then makes a curve toward the south, and crosses over to station 36, from there over to Cascade Creek and station 31, crossing slightly to the north of it; following the same direction, it runs south of station 38, and enters the metamorphic area. Its eastern termination seems to be lost under the trachyte, which subsequently invaded the region. On its north side the Cretaceous beds on the San Miguel and Rio Dolores take no part in the dips produced by the elevation along the line given. Toward the west the dips produced are not so steep as those farther east. It can be seen, however that quite frequently the line of strongest upheaval is marked by the courses of creeks, the strata dipping off on either side from them. Proceeding toward the quartzites, however, this changes. Some of the highest points of that group show their metamorphosed beds dipping off on either side of the summit to the north and south. The course of the anticlinal axis is there marked by a row of prominent peaks, prominent both on account of their altitude and the steep slopes they present. Throughout the entire older sedimentary area, south of the given line-its effect can be recognized. Although the Cretaceous beds dip off, apparently uniformly, in the same direction, unconformabilities were noticed in several instances, and it is quite probable, therefore, that their dip is to be explained by a gradual rising of that portion which then was land, rather than to be regarded as the result of the same upheaval. The fact that volcanic material at numerous places covers both the metamorphic and older sedimentary strata, resting unconformably upon them, shows that the disturbance must certainly have taken place before the time of the volcanic eruptions. On the other hand, it will be found that Cretaceous beds, appearing to have suffered no immediate dislocation from the same cause, are likewise covered by volcanic rocks of the same age, so that the appearance of the latter upon the surface could scarcely denote the extensive upheaval. Inasmuch as all the Carboniferous beds we have in the district have been affected alike, it seems correct to conclude that the anticlinal axis in question

was formed not very long after the deposition of the strata composing that formation. As to the causes to which it owes its existence, I have no explanation to offer, although I think it highly probable that its occurrence is in intimate connection with the production of the metamorphic rocks, the formation of which certainly fell into some period subsequent to the Devonian epoch.

Overlying the last-named formation, on the east side of the Animas, we find the Carboniferous beds. Analogous to those on the west side, if not identical, they commence with a series of sandstones and shales containing fragments of plants. Isolated interstrata of fossiliferous limestones occur. Higher up the heavier limestone strata are reached, and then follows the red sandstone. Referring to section I, given under the head of Devonian, we see that there is a white, coarse-grained, quartzitic sandstone, *g*, deposited upon the Upper Devonian limestone. This I regard as a good horizon to mark the beginning of the Carboniferous. Above it follow yellow to brown sandy, shales, *h*, weathering in small tabular fragments, attaining higher up more of the sandstone character, *i e.*, losing that of shales. Thin beds of limestone, containing corals, occur in the sandstones. Upon the next highest stratum, *i*, station 49 was located, at an elevation of 11,700 feet. It is a dark-blue limestone, containing *Athyris subtilida*. Its thickness is not great, amounting to 80 to 100 feet. It is covered by yellow sandstone, *l*, in which numerous fragments of plants, probably belonging to *Equisetum*, were observed. Yellow to brown sandy shales, *m*, and marls follow above this, underlying the red sandstone, *n*. Of this but little can be said, inasmuch as its stratigraphical conditions are very uniform, and the variations shown by its single beds but slight. Some of the latter show more of a shaly character, in that case having a darker color; others are more coarse-grained than is usually the case. The thickness of all these beds will amount to over 3,000 feet, of which nearly 2,000 belong to the red sandstone. Station 40 is located on this sandstone, toward the lower end of Animas Park, on the east side of the river. Dipping southward at an angle of about 6°, it does not quite reach down to the valley, but permits the underlying limestones and shales to crop out. Farther east they seem to pinch out and are not cut by section I. Descending from that station *Athyris subtilida* was found *in positu* in a thin, shaly stratum within the red sandstones, nearly one thousand feet above its lower limits. A short distance below the latter, blue limestone set in, containing numerous specimens of *Productus semistriatus*, *Athyris subtilida*, and *Spirifer*. One *Productus semistriatus* was found on station 40. *i. e.*, in the highest third of the red sandstones. It was not in position, however, and although I cannot conceive of any plausible method by which it might have been transported thence, I hesitate to accept it as positive evidence. A short distance south of station 40 the sandstone reaches the valley, and the underlying beds are hidden from view. The thickness of the Carboniferous strata exposed at station 40 is about eighteen hundred to nineteen hundred feet, nearly fourteen hundred feet of which are formed by the red sandstone. The eastern limit of the Carboniferous occurs near the Rio Vallecito and over toward Rio Pinos. Owing to very dense timber, fewer observations could be made than might have been desirable, but enough was seen to show that both vertical development and stratigraphy remain unaltered. So far as could be determined, none of the Carboniferous strata were altered by the extensive metamorphosis that took place farther north.

Ascending from Baker's Park the pass that leads into the lower val-

Section II.

Station 31.
Trachyte.

Dyke

Trachyte

Section running from Station 31 towards Sultan Mountain..9 Miles.

ley of the Animas, at an elevation of 10,460 feet the sedimentary beds are soon reached, beginning with the Devonian. Resting immediately upon it are the Carboniferous strata, beginning again with the lower series of sandstones and shales, interstratified with limestones. South of Sultan Mountain (station 26, 13,366 feet high), the strata have a southerly dip, both the Devonian and Carboniferous, while the overlying trachyte covers them, nearly horizontally stratified. Proceeding from that point to the southwest, toward station 31, it will be observed that the dip changes into an opposite direction, producing a synclinal fold. Upon reaching the station mentioned, however, it returns to such a position as to become parallel again with the first. This latter change is due to the influence of the main anticlinal axis that has been discussed above. Engineer Mountain (station 31) is located upon an isolated patch of trachyte superincumbent upon the red Carboniferous sandstones. Although no very marked stratification can be observed in the volcanic rock of that small peak, its direction is indicated by the vertical position of the columns in which the trachyte there weathers. The unconformability between the two is not so marked as farther to the northeast, owing to the fact that the eruptive material is found almost directly on the axis of upheaval. A clearer view of the respective relations can be obtained from the accompanying section II. Starting from the northeast, the metamorphic rocks, *a*, are found to underlie the sedimentaries. They are covered by Devonian limestones, *b*, containing numerous fragments of corals and *Spirifer*, analogous to the rock upon which station 48 was located. After that the Lower Carboniferous series sets in, *c*, composed of yellow to brown sandstones and shales, interstratified with beds of limestone, some of which contain *Productus semistriatus*. Heavy beds of the red sandstone, *d*, follow, showing a very considerable development of that formation. Toward station 26 these are capped for some distance by trachyte, *e*, running out on the spurs from the main group of mountains. To the north of station 31 a limestone occurs above the sandstones, exposed on but a small area, and of no considerable thickness. The absence of characteristic fossils in these strata is very much to be regretted. Crinoids and corals of a decidedly Carboniferous type were found there; but such remains by which their age could have been established definitely were not observed. Stratigraphically they are conformable to the underlying beds. During the summer of 1873, I found in the red sandstones composing a large portion of the Sangre de Cristo range, near their upper limit, beds of limestone that showed the same fossils. I am inclined to believe, therefore, that these two may be parallel; all the more as I consider the sandstones of the two regions as being of the same age. Crossing that outcrop of limestones, and proceeding northward toward the head of Bear Creek, we again descend into the region of red sandstone. All along Bear Creek it forms the high slopes on either side nearly down to the junction with Mineral Creek, dipping off gently to the west. At that point the thickness of the sandstones amounts to about 1,800 feet. Near the junction, erratic bowlders of the Lower Carboniferous limestones may be found, originating from a small outcrop of those strata on the north side of the creek. While the sedimentaries are thus found in the lower cañons, volcanic rocks form all the high points. On Bear Creek, about two miles above the junction, a conglomerate may be observed forming one of the highest strata of the sandstone group. Immediately above it the trachyte begins. By the action of the latter it has become thoroughly baked; is hard and well cemented. At no other point was a conglomerate observed in the same horizon, and it seems probable,

therefore, that it may have been a local formation. The high ridge upon which station 30 is located, dividing the waters of the San Miguel from those of the Animas, shows a volcanic cap throughout its entire length. Crossing Bear Creek Pass, the red sandstones are again found on the west side of the ridge, although their horizontal distribution is limited. As on the east side, they are covered by trachyte, which shows almost horizontal strata, slightly unconformable with the underlying sedimentary beds. Here, as well as on Bear Creek, the sandstones show a number of white interstrata, a characteristic that can be observed throughout, in the same horizon, along the exposures on the Animas. Quite considerable metamorphosis has taken place in the upper strata, produced by the overlying trachytes.

To the westward, opposite station 30, an interesting point may be observed, where apparently the Carboniferous sandstones overlie the Cretaceous beds. This is one of the instances of unconformability alluded to. The sandstones in question were deposited and raised to their present position, erosion had taken place and carved out much of the present shape, before Cretaceous waters invaded the region and the deposits of Cretaceous Nos. 2 and 3 were formed. In the cañon north of station 36, the sandstones again crop out, overlaid by Cretaceous No. 1. Farther down on the Rio Dolores, they form both the bed of the river and the banks on either side for some distance. In speaking of the volcanic area, the isolated flows near stations 36 and 37 have been mentioned. The fact that they do not stand in the same relation as regards time to the preceding sedimentary deposits, receives an additional support, inasmuch as the trachytes are found to occur, covering the Lower Cretaceous, which rests in turn upon the sandstones of the Upper Carboniferous. A number of cases were observed where the volcanic material is intrusive, which shall be referred to below.

Near station 37, which is located on the red sandstone at an elevation of 12,648 feet, this is the main rock, overlaid toward the north by the Cretaceous beds, extending southward for a considerable distance. About one-half mile north of station 37 the main anticlinal axis passes from west to east, producing a considerable dip, from 10° to 18°, in the strata. Either subsequent erosion, or a breaking of the strata, has caused the small creeks of that locality frequently to find their courses along the line of upheaval, whereas, in the quartzitic regions, the steepest peaks owe their formation to it. A section taken through station 37, in a direction of about north 30° east (section III), will explain the stratigraphical conditions of the locality. The station itself is located on a shaly stratum, *b*, contained in the red sandstones, *a*, From there the beds dip in a southerly direction, at an angle of about 12°. Traveling northward, however, a depression is soon reached, marking the line of the anticlinal axis, and from that point the strata dip off to the north. Numerous bluffs afford excellent exposures of the beds, and the characteristic change of red and white strata is well calculated to demonstrate the stratigraphy. Intrusive between the layers of the red sandstone we find a bed of trachyte, *f*, apparently interstratified, but pinching out, as the distance from the outcrop increases. Two other deposits of trachyte were seen, *f*, *f*, the one capping a narrow ridge, the other forming a small plateau. Both of them cover Cretaceous beds. Immediately upon the red sandstones the white Cretaceous, No. 1, follows, composed of a fine-grained, hard sandstone, *c*. Whether or not an unconformability exists there, was impossible to decide, as the *débris* from the latter sandstone obscured the junction at all points visited, and dense timber prevented any extensive view. Above No. 1

Trachyte

Trachyte

-achyte

Station 37

Carboniferous *Carboniferous.*

Section III.-8 Miles.

Station 37

chyte

hyto

yke

a

a

c

Section IV.

the gray shales of Nos. 2 and 3, *d*, follow, upon which the trachyte of the small plateau rests. From there westward the Carboniferous beds crop out only in the lower country, while the higher shows Cretaceous beds. This is the case also with the region lying north. An interesting case of volcanic intrusion occurs immediately south of station 37, of which section IV will give an idea. As stated above, the station is located on the red sandstones, *a*, which dip from there in a southerly direction. Descending with them a stratum of trachyte, *c*, similar to that described from station 36, is found imbedded in them, and after it is crossed the sandstones again appear. Shortly after their first outcrop has been passed, a trachytic dike, *d*, is reached, ascending nearly vertically through the sedimentary beds. From there a small point is ascended, and it will be observed that three other trachyte beds are interstratified with the sandstones. Not far from the highest portion of the hill a vertical fault has occurred, displacing the strata for the distance of about twenty to thirty feet. By this means the trachyte has been brought immediately opposite the sandstones. It was noticed that the volcanic beds diminished in thickness toward the south, some of them pinching out almost entirely by the time they reach the opposite side of the hill. A trachytic layer caps the entire series. From these and other instances where intrusion was observed, it would seem that the eruption of that isolated mass of volcanics had been accompanied by considerable dislocation, although the relative position of the latter to the sedimentary beds precludes the probability of their having had any share in the formation of the main anticlinal axis. Whence the intrusive material came is a question that may require more study to answer, but it seems to me, so far as I was able to acquaint myself with the character of the geognosy of that section, that it must have proceeded from station 36. Both from stratigraphical and lithological evidence I am inclined to accept this proposition; all the more as the mineralogical composition of all the volcanic rocks of that entire group is a remarkably uniform one.

From the localities just referred to, the Carboniferous formation extends down southward for some distance on the west side of the Animas. All along the river, from some distance above station 39 down to station 40, the lower division of the formation is exposed in the almost vertical bluffs that border the Animas Valley on the west side. Lithologically the strata show the same characteristics that are exhibited on the east side, and are, regarding the vertical distribution of beds, identical with them. Beginning again below with the series of yellow to brown shales and sandstones, the bluffs rise to a relative elevation of 1,400 to 1,800 feet above the valley. Toward the top limestones set in, containing some fossils. This formation extends westward and runs for some distance in a line approximately parallel to the course of the Animas. It is soon, however, covered by the red sandstones. A number of mineral springs, alkaline, and containing some iron, rise in the lower division. One of them is situated opposite Animas City, near the top of the bluff. Two more are found in the valley near the lower end of Animas Park, starting at the base of the bluff. While the one is cold, the other, but a short distance from it, is warm. A deposit, in part calcareous, has been formed near them.

Resting upon these Lower Carboniferous beds we again find the red sandstone, occupying, with reference to the former, the same position as on the east side of Animas. Although there may probably be some variation in the thickness of the beds, increasing as we go westward, it is not of any great extent. A large area is covered by these red sand-

stones, extending from stations 36, 37, and 31 southward along the Arimosa, its western and northern tributaries, nearly to stations 42 and 43. Densely timbered ridges, with only occasional exposures along steep banks or bluffs, mark the horizontal distribution of the formation under consideration. The drainage cuts in deeply, leaving rounded spurs and ridges to direct the future water-courses. Northwest of the junction of the A imosa with the Animas, the first outcrop of the red sandstone near the Animas Valley is observed. There it occurs as the capping of a small hill, separated from the main mass, further south, by the cañon of the Arimosa. About four miles south of station 40, the sandstones reach the level of the valley. From the northern limits of the sedimentary formations, down to this point, they have preserved an even dip to the south, varying from 4° to 12°. At this point it amounts to about 5°. As on the east side of the river, the sandstones show interstrata of white beds, arranged in the same vertical succession as there. There can be no doubt as to the identity of the formations on either side of the river. As soon as this point is established, it remains to be determined by what agency they were separated, so as to give rise to the formation of a broad valley between the two exposed walls. It has been mentioned of the Lower Carboniferous, that the bluffs it formed along the valley were nearly vertical. A considerable amount of *débris* certainly obscures the exposure of the face at the base, but presumably the same general direction is continuous. This fact holds good also for the red sandstones on one as well as the other side of the Animas. Inasmuch as the dip and strike of the strata are about the same on both sides, the former parallel to the general course of the river, and the various beds reach the valley-bottom opposite each other, it is evident that no disturbances took place by which both sides were not equally affected. The agencies by which the valley of the Animas could have been formed are: (1) gradual erosion by the river; (2) glacial action of great magnitude; (3) separation by contraction; (4) separation by directly-acting forces. Gradual erosion by the river would certainly be the first to be examined into. There were evidences found, on station 40, that at one time small erratic fragments, originating from the quartzitic group, were carried along at an elevation of nearly 1,800 feet above the present level of the valley. It is possible, however, that they might have been brought by some of the drainage flowing into the Animas from a northeasterly direction. This view is by far more plausible than that they should have been carried there by the Animas itself. On the west side no such fragments were observed. In case the valley had been formed by gradual erosion, it would seem natural that those formations yielding most readily to decomposing agents, should furnish the broadest portion of it. Such, however, is not the case, neither in the upper nor lower part of the valley. In the chapter on metamorphics, mention has been made of the evidences of former glacial action, and the granitic rocks in the Animas Valley, resembling *roches moutonnées*, near the head of the park, have been alluded to. I am in doubt, however, whether the latter owe their form to any action but that of gradual decomposition *in positu*. We have, in this instance, a metamorphic granite, stratified to so considerable an extent that the strata may easily be recognized. In addition to this, large crystals of feldspar are the predominating component mineral, and the characteristic shape of this granite, now shown at several points, can readily be accounted for, as the result of decomposition progressing under circumstances thus favorable. Nowhere throughout the region is there any positive evidence that the glacial phenomena were anything but local, and of small extent. Separation

by contraction would most likely have produced disturbances, either on one side or the other of the river. No such disturbances were observed, however. The beds show no folding or dislocation from north to south. Throughout the region the gentle dip southward is retained. A number of facts speak for a separation by directly-acting forces. On both sides of the river the formations are identical, and could the valley be reduced to a line, the two rows of bluffs on the opposite sides would be found to correspond very closely. On both sides the faces of the bluffs are nearly vertical, and there seems to be sufficient evidence that they have been so for a very long time. The nearly straight course pursued by the river since its entrance into the sedimentary country points to the fact that the formation of its first bed was probably due to some agent exercising a very considerable amount of force. Only through the older sedimentary strata has this force made itself perceptible, as the river, after leaving them, is obliged to cut its own way through the younger Middle Cretaceous beds.

About four miles north of the conflux of Junction Creek with the Animas, the Lower Cretaceous strata overlie the red sandstone unconformably, which latter extends westward to the La Plata group. There it is covered by the trachytic flows, which have their origin near the higher portions of the group, and some of which extend over into the Cretaceous area. While the volcanic rocks are stratified nearly horizontally, the sandstone still retains its southerly dip, thus producing an unconformability similar to the one east of station 31. The western limits of this formation were not reached during our work in 1874, but will probably not be found to extend much farther than the slope of the higher ridges.

A few isolated patches of the red sandstone occur in the northwestern portion of the district, showing its considerable horizontal distribution. At the upper end of the creek, a tributary of the San Miguel, and north of which station 32 was located, it crops out covered by trachyte, which forms the higher portions of the ridge running from station 30 towards Mount Sneffels. I did not succeed in establishing to my own satisfaction the relation it bore to the Cretaceous beds of that neighborhood, but from all examinations that our limited allowance of time enabled us to make, it would appear that it had been deposited and placed into its present position before the Cretaceous waters reached the locality. Another outcrop of the sandstone occurs in the Uncompahgre cañon, about five miles west of station 10. The cañon is considered inaccessible, owing to the precipitous character of its walls, the lower portion of which belongs to the formation above named. Trachyte covers it here as well as near station 32. With this the occurrence of Carboniferous beds in our district is exhausted. They are very uniform in character, and can readily be recognized, and although covering quite a considerable area, show but slight variation in vertical development.

CRETACEOUS.

This formation covers a considerable area in the district. Joining on to the southern boundary of the preceding one, it extends southward beyond the limits of our district, forming the characteristic low bluffs of that region. Some of the highest points, where the Cretaceous was found, show an elevation of 10,500 feet, while it reaches down below 6,000. As everywhere in Colorado, the single groups are well defined and characteristic, both regarding their lithological and orographic features. The southern portion, in the vicinity of the Animas, resembles more closely in the latter respect the parallel groups of other localities,

whereas the northwestern outcrops, along the San Miguel, partake more of the character of the western cañon country. Single ridges, extending for miles along the base of the older sedimentary mountains, impart to the landscape that unique appearance, that has appropriately been styled "Hog-back country." Small streams or rivers, cutting through the ridges at right angles to their general trend, separate them into rows of coffin-shaped hills, that generally have sharp crests, and regularly sloping sides. Oak-brush and piñons comprise the greater portion of the vegetation, rendering traveling a not altogether enjoyable enterprise. Wherever sandstones form the highest part of the hill, steep slopes will be formed on the north side, by virtue of the southerly dip the strata exhibit. Between the single ridges there is generally a depression, sometimes amounting to nearly 800 feet farther out into the sedimentary bluff country, of smaller dimensions, however. If the dip is gentle, it becomes more so the farther the beds are removed toward the south; table-shaped bluffs are frequently formed, falling off steeply on all sides, except the one parallel with the direction of the dip. As a means for geognostic classification these ridges answer well. It will be observed that the same strata, capping any one of them at a given point, extend to either side without changing their relative position.

Differing entirely from the features shown in this region, are those of the San Miguel neighborhood. Instead of the hog-backs and parallel ridges, the Cretaceous there forms comparatively low "flats," rising on the side toward the volcanic mountains. Deep cañons, frequently inaccessible to animals, contain the rivers and streams. In them Cretaceous No. 1 is mostly exposed, while the succeeding higher numbers overlie it, and form either gentle, grassy slopes, or are covered with young growths of timber. After the mountainous region has been passed, into which a bay of these Cretaceous beds extended, the bluff character again appears. This, however, was beyond the limits set for our work during the season of 1874. Volcanic rocks overlie these sedimentary beds at numerous points along the western border of the trachitic area, and have occasioned considerable metamorphosis. Regarding the shape and distribution of the cañons, as well as the possible causes of their formation, more shall be said in the course of this chapter. Without a comprehensive knowledge based upon the observations made over a very large extent of country, all conclusions must necessarily be the result of an argument based upon insufficient premises, and it will not be until the entire region has been carefully surveyed and mapped, that questions of the cited character can be definitely answered.

Cretaceous No. 1.

Without the appearance of either Triassic or Jurassic, we find the Cretaceous sandstones belonging to No. 1 resting immediately upon the red Carboniferous sandstone. No transitory formations whatever are in sight between the two, and I am inclined to think, therefore, that the Cretaceous waters of other regions invaded this, on the Animas, while perhaps the land at the time was too high to be reached by those of the preceding groups. From station 40, on the east side of the Animas, the bluffs opposite present a very good section, and it was from there that the relations of the different series to each other could be well studied. As shown in other sections, and treated of under the heads of "Devonian" and "Carboniferous," the sedimentary beds immediately overlie the metamorphic rocks, dipping conformably with the stratification the latter exhibit. Beginning with the Upper Devonian,

Station 40

Coal

Section V.- 12 Miles.

we pass, ascending, through the Lower Carboniferous, then through the red sandstone, and about three miles north of the conflux of Junction Creek with the Animas, reach the Lower Cretaceous beds. Up to that point the dip and strike have been conformable, but as soon as the white sandstones, belonging to No. 1, are met with, a change takes place. Although the general dip remains the same, its angle is changed to the extent of 6° to 8°. While the lowest strata show a smaller angle of dip near the top of the hill on which they crop out, they dip far more steeply a short distance farther south. From the point above given, on the western edge of Lower Animas Park, the line of Cretaceous outcrop runs along toward the northwest, the white sandstones always occupying a position high up on the hill. They are white to yellowish in color, middle to fine grained, sometimes stained in spots or stripes by hydrated sesquioxide of iron. At stations 42 and 43 their most northerly limit is reached, and their elevated position tempted the Indians to use the hills as "look-out" points. From there northward nothing but red sandstone can be found until the region of isolated trachytic eruptions is reached. Almost due west of station 42, which is located upon a small mass of trachyte capping these Cretaceous sandstones, is the La Plata group, a portion of whose volcanics covers the Carboniferous sandstone. To the southwest from the station the line of Cretaceous outcrop continues, keeping off some distance from the La Plata's. Very little variation is shown by the sandstones along the entire line of exposure. Below they are massive, weathering in heavy, partly rounded bowlders; wherever they form the capping of some bluff, and are of a more quartzitic character they break into angular fragments. Remains of plants, that cannot be recognized, however, on account of very poor preservation, are found in them. Higher up the strata are no longer so thick; and after a thickness of 800 to 1,000 feet has been passed, a bed occurs, showing indications of coal. Immediately above these sandstones the shales of Nos. 2 and 3 set in, producing, as a rule, a depression after the prominent ridge of No. 1.

On the east side of the Animas, the conditions under which No. 1 occurs are very much the same. It reaches the valley by virture of its southerly dip opposite the point where it is reached by the same formation on the west side. The succession of strata is almost identical, with this exception, that locally the indications of coal disappear. Inasmuch as their presence is due only to particularly favorable circumstances, this is by no means surprising. Here, as well as on the opposite side, the white sandstones form the highest points of a series of hills bordering upon the Carboniferous strata. Toward the top, again, the single beds become thinner, containing interstrata of shaly slates. On the face of the bluffs east of the Animas, the nonconformability was not so striking as on the west, but its existence is denoted by the difference in the angle of the dip. A section taken from station 40, (Section V,) in the direction of south 15° west, past station 44, will give an idea of the arrangement of strata. The lower strata given in the section belong to the older formations. Lower Carboniferous beds are represented, *a*, overlaid by yellow shales containing strata of limestones and sandstones, *b*, *c*, *d*. In these latter, Carboniferous fossils are found. Above them follows a deposit of blue limestone, with numerous *Productus semistriatus*, *e*, *f*, *g*, immediately underlying the red sandstones, *h*, upon which station 40 was located. One prominent stratum, of white sandstone, *i*, middle-grained, readily decomposing, is noticed among the red, while a number of smaller layers, less important, impart to the steep bluff a variegated appearance. Upon this red sandstone

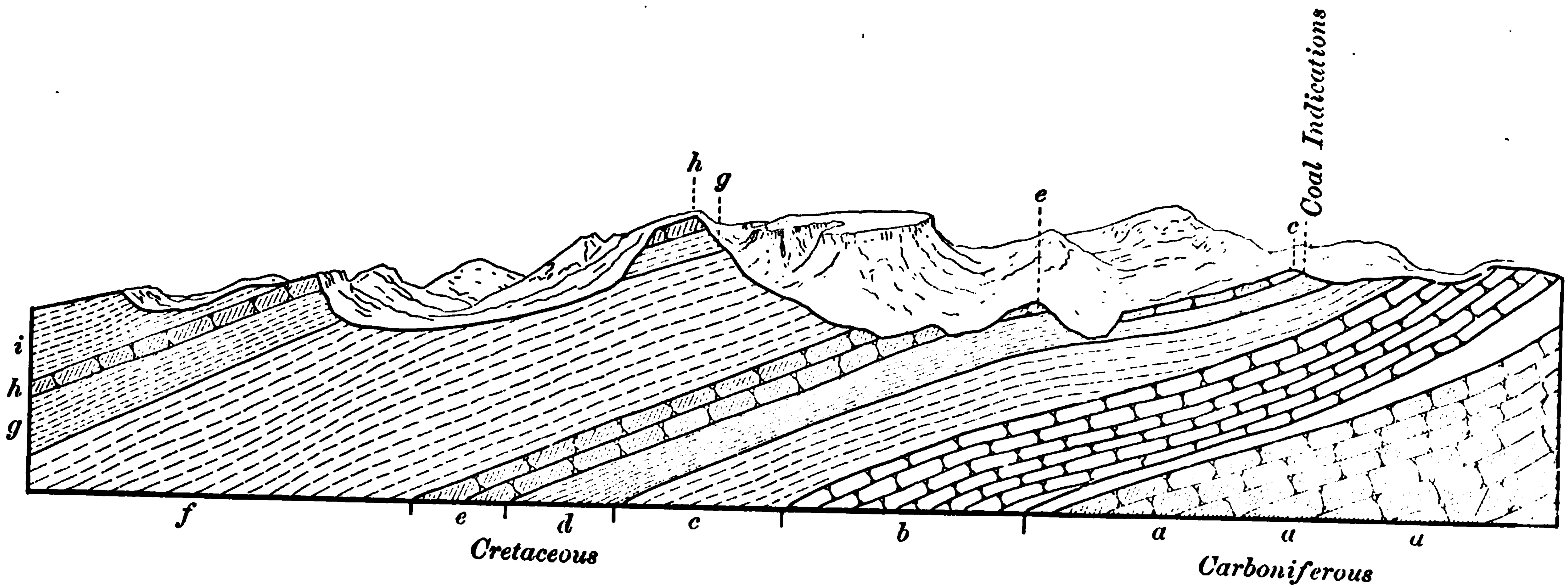
at an elevation of 8,934 feet, while camp 58, on the Florida, immediately below the station, is 7,530 feet. The shales of No. 2 have attained a very considerable development here, and are covered by the yellow sandstone, containing fragments of *Inoceramus*. For nearly a mile along the northwest face of the very steep bluff, a series of "troughs" are worn out in the shales, extending downward toward the stream. Narrow strips of the shales, from 80 to 150 feet high, separate the single "troughs." Where the steepest portion of the bluff ceases, these narrow strips show a bulging up of their ridges. Among themselves the troughs are parallel and devoid of trees, except in the vicinity of the stream. Probably they have been produced by snow-slides. An accumulation of any considerable amount of snow in a region where the sun has great power, even early in the season, could produce slides from these steep bluffs that would readily accomplish the destruction of vegetation and give rise to the formation of these trough-like depressions. In a horizontal direction the dip of the upper sandstone on these bluffs varies. Instead of being almost due south, as that of the underlying strata, it shifts to east of south on the east of the Animas, and toward the west on the other side. The older sedimentary formations extend southward in the shape of a wedge, and the younger ones dip off from them, changing their strike, as the form of this wedge may require. Ridge No. 2 runs about 22° south of west from station 47 toward the Animas, and is then continued on the other side. Station 41 is located upon a prominent point of it, 2½ miles west of the river. A section taken through station 47 (Section VI), running northwest to southeast, will show the vertical distribution of strata. Below the Cretaceous beds we find the red Carboniferous sandstone, *a*, extending eastward from station 40. Its dip is about 10°, a little east of south.

Above it appears Cretaceous No. 1, *b*, beginning with white sandstones, of less thickness than further west; but the succeeding strata, *c*, comprising yellow sandstones and shales, show a better development. In our section this forms the bed of the Florida. Traveling beyond the stream, towards station 47, a low bluff is passed, the highest point of which is formed by a yellowish sandstone, *d*, which closes No. 1. Here the dip has already increased to about 18°. Above this the gray shales, *e*, of No. 2 commence; first forming a gently-rising slope, then a steep bluff, which is capped by two strata of yellow sandstone, *f*, *g*; the lower one is shaly, scaling off in thin plates, and contains numerous remains of plants, in a very poor state of preservation, while the upper is a compact, fine-grained sandstone, weathering in rounded forms. It is the one that forms the highest portions of ridge No. 2, and upon it station 47 is located. A depression occurs beyond this, occasioned by sandy shales, *h*. Between this last stratum and the one preceding, coal is found in some localities, but here none was observed. Overlying is a bed of yellow sandstone, *i*. Probably this might correctly be regarded as the terminus of No. 2, but discrimination between the two groups becomes so difficult in this region that no positive assertion as to the precise location of the boundary can be made. Then follow two beds of yellowish to greenish shales, *k*, *l*, the lower one darker than the upper. A thick bed of yellow sandstone, *m*, forms ridge No. 3, upon which stations 44 and 45 were located, the former 3 miles east of the Animas, the latter about 6 miles west. At the point where our section cuts this ridge, it is already of less prominence than further west. Higher up in the succession of strata a series of light-colored shales, *n*, containing strata of limestones, *o*, occur, covered again by the same shales, *p*. These belong to Cretaceous No. 3, and form very characteristic "hog-

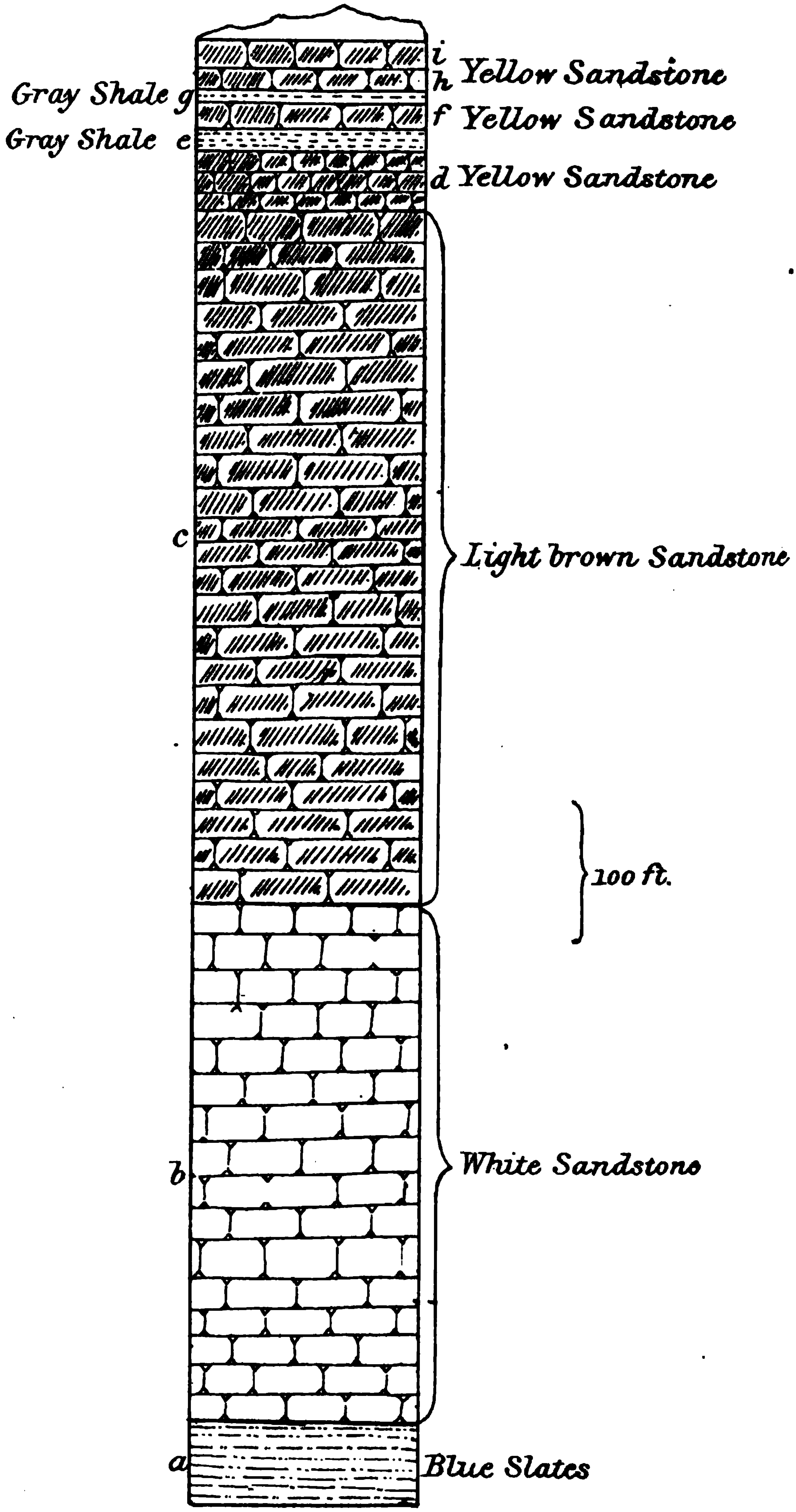
backs," closely resembling those near Cañon City. From there the Cretaceous beds begin to slope off very gently, forming low bluffs and ridges for a considerable distance. Our work did not take us beyond the third ridge. The comparative scarcity of fossils in the beds just mentioned is greatly to be regretted, because, with their aid, a more strict classification of the strata could have been obtained. During the summer of 1875, in the continuation of the geological and topographical work in Colorado Territory, this region adjoining the south will be explored, and more careful studies of the higher Cretaceous groups can be made, than were permitted by the limited time and the plan of work during 1874.

West of the Animas the ridges, that are no longer so prominent on the east side, have retained their form and relative elevation. Station 45 is nearly 200 feet higher than station 44, both being located on the same ridge, No. 3, but the latter being nine miles further east. From there onward, however, the ratio of decrease is far more rapid. The sandstone forming the summit of ridge No. 2 has given protection to the underlying shales to so great an extent, on the west side of the river, that a number of "tables" have been formed, similar in shape to those produced by a cap of basalt on some readily-decomposing sedimentary rock. On it is located station 41, south of Junction Creek. A section taken through this station, in a direction of south 30° west, (Section VII,) will give an idea both of the orographic features of the locality, and of the vertical distribution of strata. Red Carboniferous sandstone, *a*, again forms the lowest member of the section, underlying the white sandstones, *b*, of Cretaceous No. 1. Analogous to the variation on the east side of the Animas, a series of beds sets in, *c d*, comprising sandy, shaly, and argillaceous sandstones. They already show an increase in the angle of dip over that shown by the lower sandstone. A yellowish sandstone, *e*, closes Cretaceous No. 1, immediately overlying a bed of dark slaty shales, that show indications of coal. The gray shales, *f*, of No. 2 then follow, capped by the fine-grained yellow to reddish sandstone of ridge No. 2. The ridges of this sandstone are not so regular here as some distance either to the east or west, owing to the fact that frequently "tables" were formed, and subsequent erosion caused two ridges to remain, both capped by the same sandstone, *h*. Gray to greenish shales, *i*, corresponding to *k*, of section VI, follow this sandstone.

This concludes the consideration of the Cretaceous area on the Rio Animas and its tributaries. The formation varies but little in the arrangement of its members from the schedule that has been long ago established at other points, although in vertical development changes occur even within short distances. One very interesting point was studied here, the occurrence of coal. The conflicting opinions regarding the age of coal-beds in a number of more easterly and northerly localities are too well known to be dwelt upon, and it is a matter of importance, therefore, that its position here is established beyond dispute. Indications of it, and narrow seams, occur near the upper end of No. 1, below the gray shales, containing *Inoceramus* and *Gryphæa*. Again, a well-developed bed is found on the sandstone forming ridge No. 2. Whether or not this bed is continuous throughout the entire formation I am unable to say, but presume that where it is not actually developed, indications will be found upon careful search. A third bed was found by Mr. Wilson near station 45, the thickest thus far, resting near the sandstone capping ridge No. 3. For miles beyond these ridges the Cretaceous beds continue in regular succession, sloping off gently in a southerly direction, so that no doubt as to the age of the coal can be enter-



SECTION VII – 8 MILES



Section VIII.

tained. It will be of great importance now to obtain the relation of these beds to the coal-bearing strata further east, which will probably be accomplished during 1875. By that means the two horizons, if there are two, can be definitely located, and the question as to the age of the Eastern Colorado coal can be definitely solved. Mineralogically the coal is a compact bituminous one, burning with flame. Specimens obtained were taken from the surface only, as neither time nor facilities were at hand to go down upon them. Therefore any analysis that might be given would furnish a result that could not be regarded otherwise than erroneous.

Besides the Cretaceous formation in this region, it is developed on the San Miguel and on the Rio Dolores.

Ascending Bear Creek up to the pass leading over into the San Miguel region, we pass through the red Carboniferous sandstones. Trachyte overlying them is next met with, and on the west side of the divide the Cretaceous beds are reached. East of Mount Wilson, Cretaceous No. 1 appears in the cañon of the San Miguel, and as its dip is in the same direction with the course of the river, it forms its beds for a long distance. On either side the shales of No. 2 form the soil, reaching eastward to the trachytic mountains of the main group, westward to the Wilson group, and to the north far beyond the limits of our district. On the way to Mount Sneffels, we had occasion to traverse these two Lower Cretaceous numbers, and to observe their contact with the volcanic rocks. Camp was made on a creek flowing in a southwesterly direction into the San Miguel, and there it was observed that all the shales of No. 2, as well as the upper beds of No. 1, had been changed by the action of the volcanic material. The former were thoroughly baked and turned into hard slate, while the upper sandstones of No. 1 presented the appearance of quartzites. In that region the Cretaceous beds reach up into the narrow cañons, and are usually overlaid by trachyte. In the vicinity of the rivers and streams, No. 1 crops out, forming the almost inaccessible cañons through which they flow. A section taken at the junction of the above-mentioned creek and Rio San Miguel (Section VIII) will give some idea regarding the depth of the cañons and the distribution of strata. It will be noticed that the creek at which this section was taken has flown scarcely five miles, and nevertheless the depth of its cañon amounts to 1,005 feet, according to measurement. It seems, from the succession of strata, and the fact that *Inoceramus* was found in the lowest one, that not the entire No. 1 has there been developed. Beginning below, at the level of the San Miguel, we find first 50 feet of dark-blue, partly shaly limestones *a*, containing compressed specimens of *Inoceramus*. Above that follow 390 feet of white to light-yellow sandstones, *b*, fine-grained, and compact in structure, regularly stratified, having a straight dip to the northwest, conformable with that of both over and under lying beds. This is covered by 480 feet of light-brown sandstone, *c*, containing interstrata of greenish marls, underlying 40 feet of gray to yellow sandstone, *d*, weathering in grotesque forms. Above that follow a series of sandstone and shales, interchanging. The stratum mark *h*, in the section, shows indications of coal, consisting of very narrow seams of jet, and numerous coaled remains of plants. Above this the gray shales of No. 2 occur, with *Gryphæa* and numerous fragments of *Inoceramus*.

Although the question by what agents these comparatively deep cañons were formed cannot be definitely decided, without a very thorough knowledge of all their occurrences, the presence of those just mentioned, in a region so near the main mass of mountains, attracts atten-

tion. It seems incredible that a stream should have been able to erode a cañon more than 1,000 feet in depth, when the distance from its source to the point of observation is but five miles, and it furthermore seems extremely improbable that such erosion should have progressed and the walls of the cañon have remained as steep as they are at present. I am not prepared to defend any view on the subject at present, but it seems to me that an effect produced either by volcanic or plutonic earthquakes might have the same result.

About four miles below San Miguel Lake, the Lower Cretaceous sandstones set in in the cañon, and continue from there as far as it was surveyed. Crossing the divide from the San Miguel to Rio Dolores, the gray shales are traversed. At that locality they dip off to the west. The unconformability between them and the red sandstones of Carboniferous age, has been mentioned in the chapter on Carboniferous. From Mount Wilson the volcanic material has flown eastward, and covered a considerable portion of the gray shales; at the junction they are somewhat metamorphosed, but not to the extent observed in the region of Mount Sneffels. To the south of Mount Wilson No. 1 again crops out, in the cañon of the Dolores; along a number of the high ridges south of the river the characteristic white sandstones are found overlying the red sandstones, covered in turn by volcanic rocks.

From the position the Cretaceous beds along the San Miguel and Rio Dolores occupy, it is evident that they have been deposited at a time long after the upheaval that caused the formation of the main anticlinal axis above mentioned; and furthermore, it is very probable that a considerable amount of time elapsed between the two epochs.

CHAPTER IV.

MINES.

The accompanying map was kindly prepared by Mr. Wilson, to serve as an illustration for Bulletin No. 3, second series 1875. By means of lines running in different directions the geology of the region given has been represented, and an explanation thereof will be found below the title of the map. All the volcanic area, which has been treated of at some length in chapter II of this report, has been left blank.

A number of the lodes visited during the summer of 1874 have been indicated by heavy straight lines. Starting from the southeast corner of the map, near station 17, it will be observed that the metamorphics extend over from the quartzite mountains toward the volcanic area. They are mainly schistose at that locality, containing a great deal of quartz and some mica or chlorite. At several points their junction with the overlying trachyte can be seen; for instance, at the narrow ridge running southward, about four miles east of the Animas. Although the connection has been broken by overflowing trachytic materials, the metamorphics extend over into Cunningham Gulch, where they crop out. They form the great cañon of the Animas, below Silverton, that for a long time was considered inaccessible both for man and beast. Another outcrop of the same kind of rocks is found to the northwest of Handie's Peak (station 14), where granite forms the lower portions of the cañon leading down in a northerly direction from the mountain. The oldest sedimentary strata that are found within the area given by this map are the Carboniferous. Red sandstone, belonging to the upper group of this formation, occurs first about one and a half miles west of the Animas, unconformably underlying the trachyte that flowed from the north. From there it continues west and northwestward, and is exposed on Bear Creek. A blue limestone is found covering it at one point northeast of station 31. Cretaceous covers a considerable area in the western portion of the map. No. 1 is found in the deeper cañons, while the marshy or grassy soil along the San Miguel is composed of No. 2. On the banks of the Dolores and a few of its tributaries No. 1 crops out, overlying the red Carboniferous sandstone, while it is covered in turn by volcanic rocks.

At the time of my visit at the San Juan mines, August and September, 1874, but comparatively little work had been done. The greater portion of the miners' time and energy was devoted to prospecting, and but a few had then developed their lodes to any extent. One difficulty under which they labored was the want of available capital, and of a place where the ore might readily be converted into cash. It would be impossible to give any fair estimate of the number of men scattered over the country there, but I think that usually given is too high.

Mining is carried on at several points in the vicinity, and on tributaries of the Animas River. Near its head, at the so-called "Forks," is a complex of lodes (one of the early discoveries), and from it the locality has received the name of "Mineral Point." Traveling down the river for a distance of about six miles, Eureka Gulch is reached, another locality

considered by the prospectors as very promising. A settlement has been made at Howardsville, on the Animas, this being a point more favorable, perhaps, than many others, having the additional advantage of being centrally located with reference to the mines. At the bend of the Animas, near the base of Sultan Mountain, station 26, is Baker's Park proper; there is a settlement called Silverton. A short distance to the east of Silverton is Arastra Gulch, which became well known some years ago by the discovery of the "Little Giant" mine, and now contains a number of others. In a similar position to Howardsville is Cunningham Gulch, with a number of promising lodes, as yet comparatively undeveloped. Besides these points, prospecting and mining to a small extent are carried on throughout the entire vicinity, both on the mountains and in the cañons. Smelting-works were in the course of erection at Silverton when visited by our party, but, as I am informed, were not completed satisfactorily.

Geognostically, the northern portion of the district just described shows scarcely any important variation from the general character of the surrounding country. All the rocks of that part, so far as I have had occasion to observe, are volcanic, exhibiting, as at many other neighboring points, a great variety in texture and mineral constituents. From stations 13 and 14, the No. 4 of our schedule, above given, extends west and southwest, changing in lithological character, although the stratigraphical relations remain simple. I am inclined to attach considerable importance to this latter feature, all the more so, inasmuch as a satisfactory explanation of the geological relation could otherwise only be obtained after very careful detail studies. The rock upon which station 15 is located is of a grayish to muddy-green color, containing small, irregular fragments of a triclinic feldspar, and some sanidite. Cubical pyrite crystals, of about 0.3^{mm} edge, are dispersed throughout the rock, giving it, upon decomposition, a brown color.

Similar in general character, but varying in detail, are the rocks composing the mountains on either side of the Animas down to Silverton, and a short distance beyond. They are mainly aggregates, as those from station 15, sometimes containing pyrite as an impregnation. In Cunningham Gulch, the lower portions are of a dark-gray color with a greenish tinge, while the higher portions of the hills bordering the cañon are capped by the bluish strata of the higher No. 4, as described above from Handie's Peak. In Arastra Gulch the rock containing the lodes higher up on the mountain-sides closely resembles that of station 15 at some points, while at others, without any great change in the vertical direction, it answers more to the bluish variety. From all that I could observe, however, I have come to the conclusion that the lode-bearing rocks of Baker's Park belong to that trachyte series which has been designated as No. 4.

This feature of regularity disappears when we study Cunningham Gulch. Traversing the cañon, whose walls rise 3,500 feet above the creek, it will be perceived that the dark colors of the rocks still predominate, but that the lower portion of the steep walls has a tinge of gray and green, and is not horizontally stratified. This might, upon a cursory examination, lead to the conclusion that the lower rocks, showing weathering in a vertical rather than horizontal direction, were columnar trachyte. A short distance below the elevation at which the "Highland Mary" and several other lodes are located, a sharply-marked horizontal line may be observed, very slightly inclining toward the west. Above that line the rocks are horizontally stratified, varying from a bluish to a maroon color—the trachyte No. 4.

Proceeding to the head of Cunningham Creek, the volcanic rocks are seen only as forming the crests of ridges, while the main drainage runs over metamorphic rocks. Station 17, near the head of the creek just mentioned, is located on gneiss, and may be regarded as one of the outposts of the metamorphic area already mentioned. From there the line of outcrop extends east and southeast on the one side, west and south on the other. Local accumulations of mica or quartz change the lithological character of the rock, and the appearance of chlorite in it gives rise to a continuation of the metamorphic area to the southeast as chlorite schist, the rock composing the lower portions of the Cunningham walls, and containing a number of ore-veins. Farther down on the Animas, where these metamorphic rocks should be expected to crop out, within a few miles below Baker's Park, on the Animas Cañon, we find nothing but volcanics. Along either side of the river, from Cunningham Gulch downward to the point just given, volcanic rocks appear to form the entire mass in view. Although the lower portions of the rocks exposed probably do not belong to No. 3, it is very difficult to identify them with any one of the underlying groups, and they must be referred to a position near to or in intimate connection with No. 4. Owing to a large quantity of *débris* in Arastra Gulch, the majority of lodes thus far discovered have been claimed at an elevation of more than 1,000 feet above the creek. At no point in that gulch have I observed cropping out of metamorphic schists, although I have reason to believe that they really do underlie the volcanic material. This suspicion is based upon the character of the Little Giant ore, which contains chlorite and none of the minerals mostly found in the trachorheites. Prospecting has also been done farther down the river, but as my time was limited, I had no opportunity of visiting any of the lodes there located.

The conditions on the west side of the Animas appear to be of a more simple character, the metamorphic rocks not reaching over in such a manner as to crop out, although at some depth they may probably be found. It is possible that considerable erosion took place before the volcanic flows invaded the regions, and before the lodes were formed—a view which is supported by the fact that near the head of Cunningham Gulch a light blue to white limestone crops out, which, according to its lithological character, must be referred to the Upper Silurian or Lower Devonian of that region, no fossils having been found that might establish its age beyond a doubt.

The metamorphic rocks of that region, in which stations 23, 25, and 38 are located, show many variations. From a pure quartzite they pass over into micaceous schists, into gneiss, and at some points into a coarse-grained granite. Schists occur that contain the characteristic staurolite twins, scarcely to be distinguished from some eastern localities. Numerous small and large veins of white quartz traverse these schists, showing sometimes slight indications of ore.

In speaking of the lodes of the region under consideration, it is necessary to state that but little work had been done upon them; that there are existing no mines of any appreciable depth; and that but very little time could be spent upon their inspection. These facts exclude the possibility of deciding with any considerable degree of accuracy the character of the ore-bodies at any greater depth. It was necessary to make almost all studies on the immediate surface; and as from a series of such observations no law can be derived exhibiting the ratio of development as compared to the depth, it stands to reason that none definitely to be relied upon can be here given. The geological character of the veins under consideration is a very interesting one, and I

believe that the data regarding development, with depth of the mines, must necessarily afford much information on the distribution and formation of ore-bearing veins in general.

OCCURRENCE OF LODES.

Two systems, chiefly of lodes, are found, the one striking approximately northeast to southwest, the other northwest to southeast; and the two directions may be observed to occur at the same places, producing a crossing of the veins.

At all points, where none but the volcanic rocks crop out, the veins run through them in a very regular course, showing but few deviations from the straight line. Often quartz veins, containing but little ore, were observed from our high stations some distance off, keeping a regular course at times for more than a mile. As the quartz is harder than the surrounding rock, it stands out prominently, while the former, immediately adjacent, is weathered off. Decomposing pyrite imparts a brown color to the projecting ledge. As a rule, the walls may be pronounced well defined, although near the surface atmospheric influences would have the tendency to render them less so. Frequently the veins can be seen along the face of a rocky hill for several thousand feet. This was the case on a mountain opposite Howardsville, where a number of veins, some of them claimed, are visible for a vertical distance of more than 2,000 feet. The accompanying cut will illustrate their position. From the north side of the summit five parallel veins traverse the trachytic rock for a vertical distance of 1,200 to 1,400 feet, and are in their turn cut by a large vein starting from the southern side, the "Mammoth lode." Farther to the south, beyond the last named, there are several smaller veins, having an almost vertical dip. *Débris* covers the lower portion of the veins, hiding them out of sight. In Cunningham Gulch the lodes, after first running through the metamorphic rock at right angles to its strike, enter without apparent disturbance or dislocation the horizontally stratified volcanic cap. At the shallow depths which have thus far been reached, no change in the character of the ore could be observed. The stratification in Arastra Gulch is not so well marked, the rocks showing a more massive structure, although a few miles beyond its head they are regular again in their occurrence. Numerous other lodes already located occur in the volcanic rocks. The strike approximates to that above indicated. No definite relation, however, of their course to the structure of the rocks containing them could be observed.

Mineralogically speaking, the veins belong altogether to one system, with the exception of a few in Arastra and in Boulder Gulches, of which mention will be made hereafter. Minerals of a relatively low degree of volatilization form the main bulk of the ore, others, however, not being wanting.

The persistency of the veins in a vertical direction is a matter of importance, where nothing can be learned by the study of artificial depths. It appears to me that it may be regarded as a rule that wherever *débris* or some other similar cause does not obscure the view of the outcropping vein, that vein extends to considerable depths. About seventy-five lodes were located on Mineral Point, showing very promising ore from the surface downward. Sufficient work to retain the claim had been expended upon quite a number of them. Several gentlemen, G. W. Kingsbury, J. R. Hanson, A. W. Burrows, C. H. McIntyre, all from Yankton, Dakota Territory, and W. H. Van Gieson, P. Houghton, and S. H. Tuttle, from Whitewater, Wisconsin, were continuing the

FIG. 3.—METALLIFEROUS VEINS EXPOSED TO VIEW NEAR HOWARDSVILLE, COLORADO.

prospecting as well as the further developments of the veins already claimed. On Mineral Point the main strike is northwest to southeast approximately, although several lodes cross each other, and others occur, striking from northeast to southwest. As a rule, the width between walls may be stated at 4 to 12 feet, but larger veins occur. The ores mainly found are galenite, middle to fine grained, containing silver, sphalerite, from light yellow translucent to the brown varieties, pyrite, chalcopyrite, and fahlerz (brittle silver), which throughout that region appears to be an antimonial tetrahedrite, containing mainly sulphur, antimony, copper, and silver, replacements being produced by iron and zinc. About 8 to 13 per cent. of silver may be regarded as the limits within which it occurs in the pure mineral. This variety of tetrahedrite has been distinguished as freibergite.

The gangue appears to be mainly quartz. As some of the locations of that section, belonging to Eureka district, I would mention Dakota, Mineral Point, Red Cloud, Little Twinkle, Mastodon, Bond Mine, and Equator. One of the lodes on Mineral Point shows a manganese deposit on the surface (psilomelane), while farther down galenite forms the main body of the ore.

In the Placer Gulch, Burrow's Park, Adam's Park, and at the headwaters of the Uncompahgre a number of lodes have also been located, showing ore similar to those from Mineral Point and the immediate vicinity.

Upon the mines of Eureka Gulch no data could be obtained, owing to a lack of time.

Descending Cunningham Gulch, Galena Mountain is found on the right hand, while Kendall Mountain is on the left. Near the head of the gulch and on either side lodes have been located, and worked to some extent. As above mentioned, the lower portions of the cañon consist of chloritic schist, stratified, but standing on edge; while the upper portions are formed by the bluish volcanic rocks of No. 4. Several well-defined veins extend from the lower to the upper, and, as I was informed, the continuation had in two instances been traced beyond the ridge of the mountain to the other side. A considerable amount of *debris* precludes the possibility of following the veins to the bottom of the gulch, but, judging from analogy, they may be considered to extend some distance farther down beyond the point where at present they can be seen. This cañon now being one of the main routes of ingress and egress to and from Howardsville, prospectors have been attracted more particularly to the study of its vicinity, and ore has been obtained from several veins, yielding, even when taken from the surface, a comparatively large percentage of silver.

Near the head of the gulch, on the left hand descending, the

HIGHLAND MARY

is located. It has a strike of north 68° west, and vertical dip.* Between walls the gangue and ore average from 4 to 5 feet. To the northwest the extension of the vein has been found and claimed as the "Robert Bruce." Toward the gulch the Highland Mary runs through the horizontally stratified trachytes of No. 4, corresponding in character to that described from station 14, of a bluish color. The line of junction between this volcanic rock and the underlying metamorphics is well marked and readily distinguishable. Without showing any change in course or width,

* The dips are given as the variation from the vertical.

except a slight deflection of about 3 feet, forming a curve at that point, the lode can be traced downward through the schists for more than 200 feet in a vertical line. These schists are of a green color, weathering very dark. Quartz and chlorite constitute the two predominating minerals. Pyrite occurs scattered through it. Structure is slaty, with small veins of quartz traversing at right angles to the plane of the schists. After that *débris* sets in, and it would require some tunneling or other work of a similar nature to reach the vein. Galenite, intimately associated with fahlerz (tetrahedrite), at many points forms the main body of ore, and pyrite, sphalerite, and chalcopyrite are not wanting. Quartz mainly composes the gangue. The ore occurs in seams, from the thickness of a needle to 9 inches, without, however, showing any symmetry of arrangement. No further work had been done at the time of my visit than the uncovering of a number of points along the vein, in order to demonstrate the continuation of ore. It is claimed that the extension to the southeast across the cañon has been found, but I did not visit the locality.

THE ROBERT BRUCE,

as above mentioned, is the northwestern extension of the Highland Mary, keeping nearly the same course. It has been prospected for some distance, and the character of ore appears to vary but little from that found below, although the distribution of the several minerals may not be the same.

THE COMSTOCK LODE,

formerly called the Mountaineer, is situated on the same hill, about half a mile nearer to the head of the gulch, and south of the Highland Mary. Its strike is a more westerly one—north 75° west. As far as could be observed, it runs entirely in the blue trachyte. It may be, however, that the downward continuation is merely obscured by *débris*, or rather large masses of broken rocks. Between walls it is on an average 4 to 5 feet wide, and has a slight dip to the south. Very little work has been done on this lode, and mainly surface-ores, consisting of galenite, pyrite, &c., have been obtained.

THE YRETEVA

is located opposite the Highland Mary, on the east side of the gulch. It strikes a few degrees more to the west than the latter, and has the schists as wall on either side. Farther down the cañon, on Green Mountain, the

GREEN MOUNTAIN LODE

is situated, striking almost north 45° west. Lower down it runs through the schists, cutting the strike of the latter at an angle of about 80°. It continues upward through them, and enters the trachyte, without showing any perceptible change of course. The ore of all the lodes in Cunningham Gulch is of the same mineralogical character, notwithstanding the quantity and distribution of each specific mineral may frequently vary.

THE PRIDE OF THE WEST

is also located on Green Mountain, and has an approximate course of north 45° west. Though it cannot with certainty be said to reach down

into the schists, this yet appears very probable. Three hundred feet above the Pride of the West is the Equator; 150 feet below, the Astor; both running nearly parallel with the first.

Besides these, there are a number of other lodes on the Cunningham already claimed, but it was impossible to obtain notes on them all, inasmuch as the inspection of each would require nearly an entire day. This latter fact is owing to the distance at which the mines are located from any available camping-place, and from the fact that, besides being far apart, they are mostly at a considerable elevation above the creek.

We have on the Cunningham a series of silver lodes, which, so far as surface-indications may be relied upon, do not change the character of their ore when leaving the one and entering the other geognostic formation. At another locality, of which mention shall presently be made, veins containing gold-ores are found. Higher up the mountains veins appear, carrying very small quantities of this metal, but showing specific silver minerals.

In Arastra Gulch, about two and a half miles down the Animas from Howardsville, at the mouth of Cunningham, gold-mining was carried on first. The gold was washed out by various methods, until the "Little Giant" was discovered. This discovery led on to prospecting, and after some time a large number of veins had been found and claimed. In former times the settlement there was one of good promise. It decreased after the abandonment of gulch-mining, but, under the influence of these newly-discovered silver lodes, is again reviving. Although I spent as much time as I could upon the decision of the question whether the metamorphic rocks underlaid the trachytes containing the lodes, I could find no point where a satisfactory outcrop occurred. Judging, however, from the close proximity of these rocks, from their trend toward the region under consideration, and from the fact that the ore of the Little Giant is associated with chlorite, being one of the lowest mines in the gulch, I think it highly probable that they do extend through, and that the veins probably run into them. The veins observed on the higher portions of the mountains forming the walls of the short cañon run in trachyte, belonging to No. 4, and have as a rule a course of east 10° to 50° south. A number of veins occur that vary from this, but the majority preserve a parallelism among themselves. At the same time they show no material deflection from the course of neighboring veins.

THE LITTLE GIANT,

as stated, is a gold-bearing vein, situated on the northeast side of Arastra Gulch, with a course of about north 40° west. It it well known as one of the oldest mines of the region, and has yielded profits. A tunnel is driven in from the southwest, striking the lode. A short distance from the mouth of this tunnel crushing-works have been erected, crushing the ore to a powder, and as such it is then treated by amalgamation. Central and Dexter are two gold-mines east of the Little Giant.

On the opposite side of the creek, Hazelton Mountain rises to a relative elevation of 3,600 feet, and it is upon the north and northeast face of this mountain that a number of lodes are located.

EXCELSIOR LODE.

Upon this lode more work has been done than upon most others. A shaft 30 feet in depth was sunk, and a quantity of ore taken out, now

forming a small dump at the mouth of the shaft. Its course is east 39° south, and the width between walls 3½ feet. On either side the walls, even at that slight depth, are well defined, and composed of trachyte, belonging, as in Cunningham Gulch, to No. 4. The ore mainly consists of galenite, middle to fine grained, sphalerite, pyrite, chalcopyrite, and fahlerz, almost identical with the tetrahedrite mentioned above.

THE PROSPECTER

is another lode, near the preceding one, having a strike of east 31° south, and a dip of 18° to the southwest. Wall-rocks on either side are the usual trachyte, and the ore analogous to that of Excelsior.

THE PELICAN LODE

has a course of east 54° south, with a dip of 15° to the southwest. Two shafts of 18 feet each have been sunk upon the lode. For 1,500 feet the outcrop has been followed and unstripped. Among a number of other lodes that might be mentioned are McGregor, east 36° south, with a dip of 30° southwest; Aspen, east 55° south, having reached a depth of 40 feet; a shaft sunk on the lode; Pathfinder, east 30° south, curving a little southward in its course.

A tunnel has been driven from Arastra Gulch southwestward into the north face of Hazelton Mountain, with a view to cutting some of the lodes cropping out on the surface. Work is being pushed at the above-mentioned mines, although but few hands are being employed. The general character of ore is similar to that of the Cunningham mines, with the exception of those located lower down in the cañon. Other lodes are located in different portions of the gulch, but I had no opportunity to visit them.

Boulder Gulch is situated opposite Arastra, on the north side of the Animas, and contains one lode, the Crystal, that shows gangue-rock very similar to that of the Little Giant. In so far as this can be taken as an indication regarding the possible presence of the schists at some depth, it is important. Gold is the main paying metal in the Crystal.

Several localities occur, besides those mentioned, where prospecting has been done and lodes have been opened.

On Goodwin Creek, about seven miles above its junction with Lake Fork, a number of veins have been claimed, and ore was taken out. On the 15th of June, 1874, the

BIG CASINO

was located at that point on the south side of the creek, and a shaft sunk. The vein runs entirely in trachyte, which is thoroughly impregnated with pyrite. Ore has been found from the surface down, composed of galenite, sphalerite, pyrite, and fahlerz. The gangue-rock, as usual, is quartz. On the other side of the creek, the

OURAY

is situated, yielding ore of the same character, running in the same rock. Both lodes have good walls, and are worked for silver.

Near Baker's Park, on Mineral Creek, about four miles west of the park, is the Silver Court, having a strike of about north 80° east. It is situated approximately at 1,000 feet above the creek, and shows the usual ores of that region.

It may be of interest to mention that near Lime Creek, some distance down the Animas, proceeding from Baker's Park, prospecting has been done for chloride-ores, in the Devonian limestones of that region, although without any decided success. Almost all the mountains in the immediate vicinity of Baker's Park, and the regions north of it, contain veins; frequently, however, without the remunerative metals. They have been found of almost incredible width, and extending, well defined, for miles. In a country where so large an amount of mineral substance is present as in that which formed the field of our labors during the summer of 1874, it cannot be astonishing that veins or even ores should be found at any place where the conditions for their segregation and accumulation were in the least favorable.

Owing to the rugged character of the country, to the sharply-cut walls, inclosing cañons of considerable depth, and lastly to the regularity of the veins in course and dip, mining can be carried on at comparatively slight expense should the veins eventually prove as remunerative as their surface indications might justify us in presuming. A well-regulated system of sinking shafts and driving tunnels, either to or on the same vein, would afford facility for the regulation of water and air, as well as for the first transportation of ore, that ought not to be overlooked. Frequently the same vein can be taken in work from above in a vertical direction, while 1,000 feet below a tunnel driven will afford the facilities above indicated, besides furnishing valuable information as to the constancy of the ore, both in character and distribution. Timber exists in sufficient quantities to last for many mines. One unfavorable circumstance is the short duration of the season during which active work near the surface can be accomplished. After the mines have reached a certain development, however, so that their interior will be but little affected by the outside influence of atmospheric changes, a great portion of this trouble will be obviated.

In summing up all that has been observed during the short time that could be allowed for investigation of this interesting mining-region, it becomes necessary not to overlook the difficulties that had to be overcome. Above all, the fact that all the mines were but in their infancy will tend to cast a shadow over the conclusions that may have been drawn with reference to many important features. In consequence of this fact, no reliable data with reference to the vertical distribution of the ore can be given, and, although outcrops along numerous points of any lode may everywhere show favorable indications, nothing but a future development of the new mines can disperse all doubt. Regarding the persistency of the veins in a vertical direction, a sufficient number of observations have been made to lead to the conclusion that their general character in that respect is satisfactory. The ores contained in the veins are of such composition that they will offer no serious obstacles in any smelting establishment that may be founded upon principles that are not totally at variance with chemical and physical laws.

Geologically, the veins of our district are very young, probably having been formed at the close of the Cretaceous or the beginning of the Tertiary period. The enormous eruptions of the trachytic lava, covering a continuous area of more than five thousand square miles, must have taken place at the geological period above indicated. In the beginning of this paper particular stress was laid upon the impregnation with mineral matter of certain volcanic strata—a phenomenon that occurs over a large tract of country. This shows that at the time of the eruptions such conditions existed as were favorable to the formation of that class of minerals generally termed *ores*. It is furthermore to be

observed that these impregnations occur mainly in the younger strata. Although the inference cannot be drawn that the fissures were formed at the same time, or shortly after the deposition of the trachytic lava, it is allowable to assume that at such a period the material for filling these fissures was existing near the locality where but lately so thorough an impregnation had taken place. The fact that the fissures extend, at a number of points, downward, through the older metamorphic rocks, makes it improbable that they should have been formed by contraction of the cooling masses. Singular as it may seem, these lodes are devoid of that ore which is generally classed as *surface-ore.* Immediately from the surface the perfectly fresh minerals are taken out. The gangue is hard and solid. An exception is made, of course, although only to a slight extent, by pyrite, which decomposes very readily when exposed to the action of atmospheric influences. This characteristic may be explained in various ways—by the rapid decomposition and breaking off of the wall-rocks, carrying with them portions of the gangue and ore; by the less intense effects of atmospheric agencies; by the character of the minerals composing the ore, and by the comparatively short time that these fissures have been filled. The latter view is the one that would to me appear as the most acceptable.

A difficult question arises, when a decision is to be made, as to the causes that have produced the formation of the fissures that were afterward filled. Accepting, as I have always done, the theory that volcanic or plutonic earthquakes have probably produced the larger number of all lode systems—and such we have in this case—it will be necessary to find whence came the requisite force. Along the highest portion of the Quartzite Mountains we have an anticlinal axis which can be traced westward for nearly forty miles, an upheaval that must have a very perceptible effect on regions adjoining. The idea at first presented itself that this might have given rise to the formation of the fissures, but evidence subsequently discovered demonstrates that long before the eruption of the trachyte this disturbance had occurred.

About twenty miles west from the center of the mining region is a series of isolated groups of volcanic peaks. The highest one of these, Mount Wilson, reaches an elevation of 14,285 feet above sea-level, about 5,000 feet above the valley. Lithologically these groups must be considered younger than the lode-bearing rock of the Animas, and must, therefore, have become eruptive later. It seems quite possible that the disturbance produced by these eruptions may have resulted in the formation of the present fissures, which subsequently were filled from that source which supplied so much mineral matter to other neighboring rocks in the form of impregnation. It is extremely difficult to decide questions of this kind, involving so many different factors, after having made any but the most complete investigation into the subject. I therefore only offer this explanation as a suggestion, without any further elaboration.

CONCLUSION.

In the district which has been considered in the above pages, we have a comparatively regular arrangement of the various geological formations. A continuation of the volcanic area first observed in 1873, has been examined, and its southwestern borders have been determined. Adjoining that on the south is an extensive metamorphic region. Flanking both the south and west are the sedimentary formations. Although it is impossible in this case to retain any but the general outlines of a classification heretofore used in the determination of volcanic rocks, we are nevertheless enabled, by the regularity of occurrence, to parallelize them to a certain extent. It is a notable feature that the eastern portion of the volcanic region is the older, while the western—the higher one—is younger. In connection therewith, probably, is the fact observed that all outcrops of strata covered by the volcanics are unchanged sedimentaries in the eastern, while they are metamorphics in the western portion. This fact alone would, probably, prove to be a strong argument in favor of searching for the point or points of outflow in the western region. Considerable change in the *niveau* of the country must have taken place, to which allusion has been made in chapter II. Although so many features of interest are presented at almost every locality of the area, the larger portion of it, probably, centers in the mining region. We have there the case of ore-veins of certainly Post-Cretaceous age, traversing old metamorphic rocks, passing through them and entering the volcanic beds that are regarded as Tertiary. Too little is known as yet of the vertical distribution of ore in these veins to admit of any generalizations on the subject, but it seems probable that characteristic features regarding occurrence and frequency of the different minerals constituting the ores will eventually be observed. The regularity and uniformity in most characteristics that these veins present, the rarity of dislocations or faults, point to their having been formed either at or very nearly the same time. Since making the examinations in Baker's Park, the mining district of Lake Fork has been more fully developed, and the discovery of a limited number of lodes has been followed by many others that show fair indications of satisfactory results.

Difficult to study as the center of the metamorphic area may seem, sufficient evidence has been obtained near its borders to admit of a reasonable explanation of their origin. It appears that the entire Silurian series, and at many places a portion of the Devonian have furnished the material for their formation. Pure sandstones would then produce the quartzites that have given the name to that prominent group of mountains, while other rocks with more alumina, magnesia, &c., account for the granites and schists. Were it possible, on account of time and the rugged character of the country, together with its superabundance of rain, to make the requisite detail investigations, I think the question might be fully solved and much applicable information gained.

Mention has been made of the glacial phenomena observed in the Quartzite group. Although they are limited to small areas their influence on shaping the drainage, and, by changing the surface of the ground, producing lakes and swamps, has been quite considerable.

More varied in its single members than the preceding group is the sedimentary portion of the district. Stratigraphically it is quite simple.

A few local disturbances occur, but besides those only the great anticlinal axis is an object of interest. Although the Cretaceous beds of the southern and western portion have the same general direction of dip as the older ones, several localities have furnished evidence that the disturbances affecting the Devonian and Carboniferous must have occurred before the deposition of the Cretaceous. It is possible that to this fact, to the higher relative position at the time, the absence of Triassic and Jurassic beds may be attributed.

Regarding the different members of the older sedimentary formations much might be said about their mutual affinities. The highest Devonian has a decidely Carboniferous aspect, while, on the other hand, the lowest Carboniferous shows affinities to the Devonian.* I have considered it best to draw the line of distinction there where we have characteristic fossils to aid discrimination in the future. Of the red sandstone referred to the Carboniferous mention has often been made in the preceding pages. Based mainly upon stratigraphical evidence, which, it is true, is supported by meager paleontological proof, I regard that series of sandstones as a member of the Upper Carboniferous formation. It is, so far as I am able to determine, the same that in 1873 I distinguished as Arkansas sandstone.

During the coming field-season (1875) I hope to see more of this group, and may succeed in establishing its age beyond doubt.

Some doubts have arisen as to the classification of the Cretaceous beds in the southern portion, along the Animas. Inasmuch, however, as I have not yet seen the entire series there, and will probably have occasion to do so during the next field-season, I shall postpone the discussion of this subject.

* Compare: Report United States Geological and Geographical Survey, 1873, page 341.

REPORT OF SAMUEL AUGHEY, Ph. D.

THE SUPERFICIAL DEPOSITS OF NEBRASKA.

By Samuel Aughey, Ph. D.

The casual observer, passing over Nebraska, little suspects the marvelous histories treasured up in the rocks beneath his feet. These underlying rocks represent four great divisions of geological history. Commencing at the southeastern part of the State, and going westward and northwestward, these divisions are, Upper Carboniferous, Permian, Cretaceous, and Miocene and Pliocene Tertiary. The reader is referred to the geological map found in Hayden's final Report on the Geology of Nebraska, for the boundaries and extent of these deposits. In Hayden's reports will also be found the descriptions of these deposits and the story of the extraordinary life of past times which they unfold.

The purpose of this paper is only to give some of the prominent features of the surface geology of the State ; and, therefore, the older rocks are only referred to in the case of the Miocene and Pliocene deposits, where they constitute the surface in the bad lands in the northwestern corner of the State. Nebraska owes the peculiarity of its surface and its great fertility mainly to three deposits, namely, the Drift, Loess, and Alluvium. The poorer portions are principally produced by the sand-hills, bad lands, and alkali lands. These deposits will be considered in the order mentioned.

THE DRIFT.

The Drift is the most widely-diffused geological deposit in the State. It constitutes the surface-soil in some places, but generally it is found directly below the Loess. In rare instances it seems to have been removed from the uplands by denudation before the Loess was formed. Sometimes where it is exposed at the surface it is so mingled with the Loess, Alluvium, and organic matter as to escape the attention of any one save a practical geologist. It ranges in thickness from a few inches to seventy-five feet. It may be much thicker, but if so I have seen no exposures that indicate it. Nowhere does it come to the surface over wide areas. In the northern part of the State it occasionally constitutes the surface, in the southern part of Dixon County, in the northern part of Wayne, and in portions of Cedar, Knox, Pierce, Antelope, and Holt Counties. In townships 30 and 31 north, range 1 and 2 east, in Cedar County, semicircular rows of Drift pebbles and bowlders even yet extend across narrow valleys, that lie on the flanks of high bluffs in the form of terminal moraines of glaciers, the marks of which unnumbered centuries have not been able to efface. In this region some of the glacier-marked bowlders are of great size, weighing many tons. One of the most remarkable lies near the quarter-section stone, between sections 25 and 36, in township 30 north, range 1 east. It lies on top of the highest bluff in this region, from which there is a magnificent view of the whole country around. It is a granitic quartzose rock, about four feet square. On the level top-surface there is a beautiful engraving of a child's foot, a half-moon, a grape-vine, and other

hieroglyphics. The engraving of the child's foot is cut in its deepest part, three-fourths of an inch into the hardest rock, and for fidelity to nature it would do honor to the work of a Greek artist. Previous to my discovery of this relic of the past (1869), no one in that region had heard of its existence. It may have been the work of the mound-builders, as their peculiar pottery and mounds are found near by, but what implements enabled them to carve these symbols in this hard rock, as well as the purpose of such a monument at such a place, will probably always remain a mystery.

South of the Platte the Drift creeps to the surface on some of the hill-sides of Lancaster, Saunders, Saline, Butler, Gage, Seward, Johnson, Pawnee, and Jefferson Counties. In fact, there are few counties in the eastern part of the State where the Drift is not occasionally exposed by denudation. Four miles northwest of Nebraska City, on the farm of Hon. J. F. Kinney, is a granitic bowlder as large as a small house, on whose top smooth holes have been worn by the Indians in grinding or pounding corn. This bowlder is imbedded in a Loess deposit, through which it extends from the Drift below. Here, as in most other regions, the Drift varies a great deal in character. As already intimated, it has here been so modified by subsequent lacustrine agencies as generally to be capable of high cultivation. Recently I have made a special examination of the modified Drift in Johnson County. Where the ground was covered with pebbles, the spade showed that the soil beneath was composed largely of Loess materials, mingled with Drift sand and clay, and organic matter. Here it is often in layers, showing that it is genuine modified Drift. This modified Drift soil, during the last season, where it was well cultivated, yielded sixty bushels of corn to the acre. It is only inferior, if inferior at all, to the Loess, which will be considered in the next section. Where this Drift is the purest, it is composed of bowlders, some of which are of large size, pebbles, gravel, sand, and a small per cent. of alumina. In places the Drift contains considerable lime, which was, no doubt, produced by the disintegration during glacial times of the Niobrara division of Cretaceous rocks. Sometimes fragments of these Cretaceous rocks are found in the Drift. Generally the pebbles and bowlders are composed of the primary rocks, such as quartz, quartzose, granite, greenstone, syenite, gneiss, porphyry, actinolite, &c. Occasionally the near presence of the Drift is indicated by large bowlders sticking up through soil composed of very different material. In such cases I have learned by experience to look for the modified Drift which is so valuable in the agriculture of this State. In the few localities where all the finer matter has been removed by water agency, numbers of the different forms of variegated agates, carnelians, jaspers, sardonyx, onyx, opals, and petrified wood, &c., are found. Agates and petrified wood are specially abundant. The latter is found almost in every exposure of the Drift. Some of the agates vie in beauty with those obtained from the most celebrated localities in the mountains. Judging from the remains of the matrix still attached to some of them, they were originally formed in the primary rocks, from which they were separated by the disintegration to which they were subjected by the wear and tear of the elements in glacial times.

The scratchings on top of the rocks along the Platte and other rivers where I have been able to examine them, indicate that the general direction of the glaciers was from 19° to 27° east of south. The only exception to this direction that I have found was in Stout's stone-quarry, twelve miles southeast of Lincoln, on the Nebraska Railroad, where the motion seems to have been 13.5° degrees east of south.

A brief description of a remarkable section through the Drift on Oak Creek, Lancaster County, will not be out of place. A few miles from Lincoln the terrace on this creek, composed of Loess materials, approaches the creek very closely. In this well the Loess deposit was fifteen feet in thickness, then came two feet of Drift, then two feet of compact peat, then clay and black soil, and then Drift again. The lower Drift here probably represents the period of the first glacial advance. The clay, black soil, and peat represent the middle period when the glaciers had retreated and a new forest-bed covered the State. The Drift, immediately on top of this, marks the second advance of the glaciers. The Loess on top represents the final retreat of the glaciers, and that era of depression of the surface of the State when the greater part of it constituted a great fresh-water lake into which the Missouri, the Platte, and the Republican Rivers poured their waters.

THE LOESS DEPOSITS.

The Loess deposits first received this name from Lyell, who observed it closely along the Mississippi in various places. Hayden frequently calls it the bluff formation, because of the peculiar configuration that it gives to the uplands which border the flood-plains of the rivers. He also frequently calls them marl-beds. This deposit, although not particularly rich in organic remains, is in some respects one of the most remarkable in the world. Its value for agricultural purposes is not exceeded anywhere. It prevails over at least three-fourths of the surface of Nebraska. It ranges in thickness from five to one hundred and fifty feet. Some sections of it in Dakota County measure over two hundred feet. At North Platte, 300 miles west of Omaha and on the south side of the river, some of the sections that I measured ranged in thickness from one hundred and twenty-five to one hundred and fifty feet. From Crete, on the Burlington and Missouri River Railroad, west to Kearney, on the Union Pacific Railroad, its thickness for 90 miles ranges from forty to ninety feet. South of Kearney, and for a great distance west, along the Union Pacific Railroad as far as to the Republican, there is a great expanse of territory covered by a great thickness of this deposit. I measured many sections in wells over this region and seldom found it less than forty, and often more than sixty feet in thickness. Along the Republican I traced the formation almost to the western line of the State, its thickness ranging from thirty to seventy feet. One section north of Kearney, on Wood River, showed a thickness of 50 feet. The same variation in thickness is found along the counties bordering on the Missouri. One peculiarity of this deposit is that it is almost perfectly homogeneous throughout, and of almost uniform color, however thick the deposit, or far apart the specimens have been taken. I have compared many specimens taken 300 miles apart, and from the top and bottom of the deposits, and no difference could be detected by the eye or by chemical analysis.

Over 80 per cent. of this deposit is very finely comminuted silica. When washed in water left standing, and the water poured off, and the coarser materials have settled, the residuum, after evaporation to dryness, is almost entirely composed of fine siliceous powder. So fine, indeed, are the particles of silica that its true character can alone be detected by analysis or under a microscope. About 10 per cent. is composed of the carbonates and phosphates of lime. These materials are so abundant in these deposits that they spontaneously crystallize, or form concretions, from the size of a shot to that of a walnut; and these are often hollow or contain some organic matter, as a fossil, around which the crystalliza-

tion took place. Almost anywhere, when the soil is turned over by the plow or in excavations, these concretions may be found. Often, after a rain has washed newly-thrown-up soil, the ground seems to be literally covered with them. Old gopher hills and weather-beaten hillsides furnish these concretions in unlimited quantities for the geologist and the curiosity hunter. When first exposed, most of these concretions are soft enough to be rubbed fine between the fingers, but they gradually harden by exposure to the atmosphere. This deposit also contains small amounts of alkaline matter, iron, and alumina. For the purpose of showing the homogeneous character and the chemical properties of the Loess deposits, I have made five new analyses of this soil. No. 1 is from Douglas County, near Omaha; No. 2 from the bluffs near Kearney; No. 3 is from the Lower Loup; No. 4 from Sutton, and No. 5 from the Republican Valley, near Orleans, in Harlan County.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Insoluble (siliceous) matter	81.28	81.32	81.35	81.30	81.32
Ferric oxide	3.86	3.87	3.83	3.85	3.86
Alumina	.75	.75	.74	.73	.74
Lime, carbonate	6.07	6.06	6.03	6.05	6.09
Lime, phosphate	3.58	3.59	3.58	3.57	3.59
Magnesia, carbonate	1.29	1.28	1.31	1.31	1.29
Potassa	.27	.29	.35	.34	.33
Soda	.15	.16	.14	.16	.16
Organic matter	1.07	1.06	1.05	1.06	1.06
Moisture	1.09	1.08	1.09	1.08	1.09
Loss in analysis	.59	.54	.53	.55	.47
	100.00	100.00	100.00	100.00	100.00

Since making the above analyses I have received from Dr. Hayden his Final Report on the Geology of Nebraska. This report, on page 12, contains two analyses of the Loess deposit, from Hannibal, Missouri, made by Dr. Litton. According to this analysis, from one hundred parts there were—

	No. 1.	No. 2.
Silica	76.98	77.03
Alumina and peroxide of iron	11.54	12.10
Lime	3.87	3.25
Magnesia	1.68	1.63
Carbonic acid	Not determined.	2.83
Water	2.01	2.43
	96.17	99.26

According to this analysis the Loess contains more clay in Missouri than it does in Nebraska.

For the purpose of comparison, I here reproduce, from Hayden's report, Bischoff's analyses of the Lacustrine or Loess of the Rhine:

	No. of analysis.				
	1.	2.	3.	4.	5.
Silicic acid	58.97	79.53	78.61	62.43	81.04
Alumina	9.97	13.45	15.26	7.51	9.75
Peroxide of iron	4.25	4.81		5.14	6.67
Lime	0.02	0.03	....	....	....
Magnesia	0.04	0.06	0.09	0.21	0.27
Potash	0.11	1.05	3.31	1.75	2.97
Soda	0.81	1.14			
Carbonate of lime	20.16	....	....	11.63	....
Carbonate of magnesia	4 21	....	....	3.02	....
Loss by ignition	1.37	....	1.89	2.31	....

It will be seen from the above analyses of Bischoff that Nos. 3 and 5, in the quantity of silica and other elements that are present, come very near the Loess of Nebraska. The principal difference is the larger quantity of alumina present in the samples analyzed by Bischoff. Chemically the deposits of the Rhine Valley, as Hayden remarks, are not essentially different from those of the Loess soils along the Missouri.

As would be expected, from the elements which chemical analysis shows to be present in these deposits, it forms one of the best soils in the world. In fact, it can never be exhausted until every hill and valley of which it is composed entirely worn away. Its drainage, which is the best possible, is owing to the remarkably finely-comminuted silica of which the bulk of the deposit consists. Where the ground is cultivated the most copious rains soon percolate through the soil, which, in its lowest depths, retains it like a huge sponge. Even the unbroken prairie absorbs much of the heavy rains that fall. When droughts come the moisture comes up from below by capillary attraction. And when it is considered that the depth to the solid rock ranges generally from five to two hundred feet, it is seen how readily the needs of vegetation are supplied in the driest seasons. This is the main reason why over all the region where these deposits prevail the natural vegetation and the well-cultivated crops are rarely dried out or drowned out. I have frequently observed a few showers to fall in April, and then no more rain until June, when, as will be considered farther on, there is generally a rainy season of from two to four weeks' continuance. After these June rains little more would fall till autumn; and yet, if there was deep and thorough cultivation, the crops of corn, cereals, and grass would be most abundant. This condition represents the dry seasons. On the other hand, the extremely wet seasons only damage the crops over the low bottoms, subject to overflow. Owing to the siliceous nature of the soils they never bake when plowed in a wet condition, and a day after heavy rains the plow can again be successfully and safely used.

The physical properties of the Lacustrine deposits are also remarkable. In the interior, away from the Missouri, hundreds of miles of these Lacustrine deposits are almost level or gently rolling. Not unfrequently a region will be reached where, for a few miles, the country is bluffy or hilly, and then as much almost entirely level, with intermediate forms. The bluffs that border the flood-plains of the Missouri, the Lower Platte, and some other streams are sometimes exceedingly precipitous, and sometimes gently rounded off. They often assume fantastic forms, as if carved by some curious generations of the past. But now they retain their forms so unchanged from year to year, affected neither by rain nor frost, that they must have been molded into their present outlines under circumstances of climate and level very different from that which now prevails.

For all purposes of architecture this soil, even for the most massive structures, is perfectly secure. I have never known a foundation of a large brick or stone building, if commenced below the winter frost-line, to give way. Even when the first layers of brick and stone are laid on top of the ground there is seldom such unevenness of settling as to produce fractures in the walls. On no other deposits, except the solid rocks, are there such excellent roads. From twelve to twenty-four hours after the heaviest rains the roads are perfectly dry, and often appear, after being traveled a few days, like a vast floor formed from cement, and by the highest art of man. The drawback to this picture is that sometimes during a drought the air along the highways on windy days is filled with dust. And yet the soil is very easily

worked, yielding readily to the spade or the plow. Excavation is remarkably easy, and no pick or mattock is thought of for such purposes. It might be expected that such a soil readily yielded to atmospheric influences, but such is not the case. Wells in this deposit are frequently walled up only to a point above the water-line; and on the remainder the spade-marks will be visible for years. Indeed, the traveler over Nebraska will often be surprised to see spade-marks and carved-out names and dates years after they were first made, where ordinary soils would soon have fallen away to a gentle slope. This peculiarity of the soil has often been a God-send to poor emigrants. Such often cut out of the hillsides a shelter for themselves and their stock. Many a time when caught out on the roads in a storm, far away from the towns, have I found shelter in a "dug-out" with an emigrant's family, where, cozy and warm, there was perfect comfort, with little expenditure of fuel on the coldest days. In summer such shelters are much cooler than frame or brick houses. I shall never forget one occasion in 1866, when bewildered by a blinding snow-storm I came to a "dug-out," and although all the chambers were carved out of the soil (Loess) they were perfectly dry. The walls were hidden and ornamented with Harper's Weekly, with the emanations of Nast's genius made to occupy the conspicuous corners. My hostess, whose cultivated intellect and kindly nature made even this abode a charming resort, was a graduate of an eastern seminary. Her husband, after a failure in business in New York, came here to commence life anew on a homestead by stock-raising. To get a start with young stock no money could be spared for a house. Eight years afterward I found the same family financially independent and living in a beautiful brick mansion, but I doubt whether they had any more substantial happiness than when they were looking for better days in the old temporary "dug-out." Thousands who are still coming into this land of promise are still doing the same thing. So firmly does the material of this deposit stand that after excavations are made in it, under-ground passages without number could be constructed without meeting any obstacles and without requiring any protection from walls and timber.

Cause of these peculiarities.

These peculiarities of the Loess deposits are chiefly owing to the fact that the carbonate of lime has entered into slight chemical combination with the finely comminuted silica. There is always more or less carbonic acid in the atmosphere which is brought down by the rains, and this dissolves the carbonate of lime, which then readily unites with silica, but only to a slight extent, and not enough to destroy its porosity. Though much of the silica is microscopically minute, it has largely preserved its angular structure, and this of course aids the slight chemical union that takes place between it and the carbonate of lime. Had there been more lime and iron in this deposit, and had it been subjected to greater and longer pressure from superincumbent waters, instead of a slightly chemically compacted soil it would have resulted in a sandstone formation incapable of cultivation. There is not enough clayey matter present to prevent the water from percolating through it as perfectly as through sand, though a great deal more slowly. This same peculiarity causes ponds and stagnant water to be rare within the limits of this deposit. Where they do exist in slight depressions on the level plain, it is found that an exceptionally large quantity of clayey matter has been accumulated in the soil on the bottom. In Clay, Fillmore, York, and a few other counties there are considerable numbers of ponds, covering from a few acres to half a section of land, grown up around the border with reeds

and coarse grasses and sedges, and where the water is deeper, with arrow-leaves, pond-lilies, and other water-plants. In every instance where I had opportunity to examine them, there was a thin bed of clayey matter mixed with organic materials, from a few inches to a foot or more in thickness, lying on the bottom, and on top of the Loess deposit. This clayey matter was probably deposited there before the waters finally retired from the old lake-bed in which this soil originated. In the stiller portions of the lake, or in eddies, about the time it commenced to become dry land, when portions were already cut off from the main lake, except in flood-time, in these isolated pools all the clay in solution would be precipitated to the bottom, before the next annual rise of the waters. This I propose as a provisional explanation of this phenomenon.

Fruit on the Loess deposits.

In these Loess deposits are found the explanation of the ease with which nature produces the wild fruits in Nebraska. So dense are the thickets of wild grapes and plums along some of the bottoms and bluffs of the larger streams that it is difficult to penetrate them. Over twenty varieties of wild plums have been observed, all of them having originated either from *Prunus americana*, *P. chickasa*, or *P. pernillo*. Only two species of grapes are clearly outlined, namely, *Vitis aestivalis* and *V. cardifolia*, but these have such interminable variations that the botanist becomes discouraged in attempting to draw the lines between them, and to define the range and limit of the varieties. The same remark could be made of the strawberries. Raspberries and blackberries abound in many parts of the State. The buffalo-berry (*Shepherdia canadensis*) is common on many of the Missouri and Republican River bottoms. Many other wild fruits abound, and grow with wonderful luxuriance wherever timber protects them and prairie-fires are repressed. As would be expected, these deposits are also a paradise for the cultivated fruits of the temperate zones. They luxuriate in a soil like this, which has perfect natural drainage, and is composed of such materials. No other region, except the valleys of the Nile and of the Rhine, can, in these respects, compare with the Loess deposits of Nebraska. The Loess of the Rhine supplies Europe with some of its finest wines and grapes. The success that has already attended the cultivation of the grape, in Southeastern Nebraska, at least, demonstrates that the State may likewise become remarkable in this respect. For the cultivation of the apple its superiority is demonstrated. Nebraska, although so young in years, has taken the premium over all the other States in the pomological fairs at Richmond and Boston. Of course there are obstacles here in the way of the pomologist as well as in other favored regions. But what is claimed is, that the soil, as analysis and experience prove, is eminently adapted to grape, and especially to apple-tree culture. The chief obstacle is particularly met with in the interior of the State, and results from the climate. In mid-summer occasional hot, dry winds blow from the southwest. These winds, where the trunks of apple-trees are exposed, blister and scald the bark on the south side, and frequently kill the trees. It is found, however, that when young trees are caused to throw out limbs near to the ground, they are completely protected, or if that has not been done, a shingle tacked on that side of the tree prevents all damage from that source. Many fruit-growers also claim that cottonwood and box-elder groves on the south side of orchards is all that is necessary to protect them from these storms. I mention this here to put any new settler, who may read this and who has not learned the experience of fruit-growers in this State, on his guard.

Scenery of the Loess deposits.

It has been remarked that "no sharp lines of demarkation separate the kinds of scenery that produce the emotions of the grand and the beautiful." This is eminently true of some of the scenery produced by the Loess formations. Occasionally an elevation is encountered from whose summit there are such magnificent views of river, bottom, forest, and winding bluffs as to produce all the emotions of the sublime. One such elevation is Pilgrim Hill, in Dakota County, on the farm of Hon. J. Warner. From this hill the Missouri bottom, with its marvelous, weird-like river, can be seen for twenty miles. Dakota City and Sioux City, the latter distant sixteen miles, are plainly visible. If it happens to be Indian summer, the tints of the woods vie with the hazy splendor of the sky to give to the far outstretched landscape more than an oriental splendor. I have looked with amazement at some of the wonderful cañons of the Rocky Mountains, but nothing there more completely filled me and satisfied the craving for the grand in nature than did this view from Pilgrim Hill. Another view equally majestic is on the Missouri, back of Iona, in Dixon County. My attention was directed to it by John Hill, esq., who took me to the West point for observing the river, which can here be seen for a great distance. The alternations of lofty bluff and bottom, woodland and prairie, give a picture worthy the pencil of the most gifted artist, and of all who love the grand and picturesque in nature. It is true that such scences are rare, but then there are many landscapes which, if not grand, are still of wonderful beauty. This is the case along most of the bluffs of the principal rivers. In Northern Nebraska these bluffs often reach two hundred or more feet in height, and this perhaps gives this portion of the State the most varied scenery. At some points these bluffs are rounded off and melt beyond into a gently-rolling plain. But they constantly vary, and following them you come now into a beauful cove, now to a curious headland, then to terraces, and, however far you travel, you in vain look for a picture like the one just passed. Numerous rounded tips, with strangely precipitous sides, are seen in every hour's travel, and these, as they form bold curves, rampart-like, stretch away into the distance and form images of the most impressive beauty. Indeed the bluffs of the Loess deposits are unique, and Ruskin cannot exhaust the subject of the beautiful until he sees and studies the hills of Nebraska.

Origin of the lacustrine deposits.

The geological discoveries of the last decade, and especially those of Dr. Hayden, indicate that there have been no breaks in geological history. If this view is correct, then the Glacial age was not suddenly inaugurated, as was once held. At least, during the latter portion of the Pliocene age, the temperature was steadily falling from year to year. It may have been so slow as to be only perceptible in the course of centuries. Finally, however, glaciers formed in the polar regions. Gradually, by the continually-falling temperature, these glaciers crept southward from the polar regions, until, in the course of ages, they covered the whole land down to perhaps the thirty-fifth degree of north latitude. It was during this period that, perhaps, most of the glacial scratches and other markings of these times, so familiar to the geologist, were made all over the north temperate zone, from the thirty-fifth degree towards the pole. After the glaciers had done their work, during a period whose length is undetermined, a new change of level and of climate was inaugurated, and the ice-fields began to wane and gradually

to disappear. This entire region became so depressed that the greater part was submerged. How long this submergence lasted is an unsolved problem. As the land in the course of ages emerged again from the waters, under the influence of a milder climate, it gradually became covered with a vast forest. The bed of this old forest is often struck in digging wells in many parts of the West. It is often found in the glacial Drift, and separates it into two portions. It is composed of black soil, and where I have measured it, its thickness ranged from six inches to three feet. It often contains partially decayed and partially or entirely petrified wood. Over this old and now buried forest-bed the elephant (*Elephas americanus*) and mastodon (*Mastodon americanus*) roamed in company with the reindeer and musk-ox. A back molar of the left side of the lower jaw of an elephant, obtained from this old bed in Saline County, which is in the university cabinet, measures seventeen inches from front to rear. But the slow upward movement of the land, accompanied by a gradually-falling temperature, inaugurated a second advance of the glaciers, which "wiped out" the forests that covered the land. This period was followed by a still greater subsidence of the land toward the north, when the glaciers began to disappear the second time. According to Professor Newberry, who has profoundly studied this question, all that region north of the Ohio, and westward beyond the Missouri, which is now less than eleven hundred feet above the level of Lake Erie, was covered with water. The depression was greatest toward the north, so that in the east the Alleghanies, and their dependent foot-hills, and a wide area of low country toward the south and west, formed a shore-line to the interior sea of the period. This sea was often covered with floating icebergs, which, melting, dropped their imbedded sand, gravel, and bowlders to the bottom. The old controversy concerning the method by which the glacial Drift was formed had on both sides some elements of truth. It was formed exclusively by neither glaciers nor icebergs, but by both operating at different times in their own peculiar way.

From this submergence the land slowly arose, and when the Missouri, the Platte, and the Republican Rivers in their upper courses resumed their work the Lacustrine age commenced. There is, of course, no exact line where the one ends and the other begins, but it is safe to say that the later centuries of this great subsidence witnessed the deposition of the Loess deposits. When it commenced, the greater part of Iowa had become dry land. What was left of this great sea was the western portion of Iowa, a large portion of Nebraska, and the various lakes along the Missouri, in the States through which it flows on its way to the Gulf. The Missouri, and sometimes the Platte, have been among the muddiest streams in the world. If we go up the Missouri to its source, and carefully examine the character of the deposits through which it passes, we cannot be surprised at its character. These deposits being of Tertiary and Cretaceous ages, are exceedingly friable and easy of disintegration. The Tertiary, and especially the Pliocene Tertiary, is largely siliceous, and the Cretaceous is both siliceous and calcareous. In fact, in many places the Missouri and its tributaries flow directly over and through the chalk-beds of the Cretaceous deposits. From these beds the Lacustrine deposits no doubt received their large per cent. of the phosphates and carbonates of lime. Flowing through such deposits for more than a thousand miles, the Missouri and its tributaries have been gathering for vast ages that peculiar mud which filled up their ancient lakes, and which distinguishes them even yet from most other streams. Being anciently, as now, very rapid streams, as soon as they emptied themselves into these great lakes, and their waters became

quiet, the sediment held suspended was dropped to the bottom. While this process was going on in the earlier portion of this age, the last of the glaciers had probably not retreated farther than the headwaters of the Platte, the Missouri, and the Yellowstone. The tremendous force of these mighty rivers was, for a while at least, aided by the erosive action of ice, and therefore must have been vastly more rapid at times than anything of the kind with which we are now acquainted. The following analysis of Missouri River sediment taken at high stage will show, by comparison with the analyses of the Loess deposits, what a remarkable resemblance there is even yet between the two substances.

In one hundred parts of Missouri River sediment, there are of—

Insoluble (siliceous) matter	82.01
Ferric oxide	3.10
Alumina	1.70
Lime, carbonate	6.50
Lime, phosphate	3.00
Magnesia, carbonate	1.10
Potassa	.50
Soda	.22
Organic matter	1.20
Loss in analysis	.67
	100.00

Two other analyses which I made, the one from sediment at high water and the other at low water, differ somewhat from this, but in essential particulars are the same. This identity of chemical combinations also points to the remarkable sameness of conditions that have existed for long periods in the Upper Missouri and Yellowstone regions.

After these great lakes were filled with sediment (Missouri mud), they existed for a longer or shorter time as marshes or bogs. Isolated portions would first become dry land, and as soon as they appeared above the water they were, no doubt, covered with vegetation, which, decaying from year to year, and uniting under water or at the water's edge with the deposits at the bottom, formed that black soil so characteristic of Nebraska prairies. For it is well known that when vegetable matter decays in water or a wet situation its carbon is retained. In dry situations it passes into the atmosphere as carbonic-acid gas. After the first low islands appeared in this old lake, they gradually increased from year to year in size and numbers. The ponds and sloughs, some of which could almost be called lakelets, still in existence, are probably the last remains of these great lakes. These ponds, where they do not dry up in midsummer, swarm with a few species of fresh-water shells, especially of the *Limnæs*, *Physæs*, and *Planorbi*, which to me is strong proof of this theory of their origin. The rising of the land continuing, the rivers began to cut new channels through the middle of the old lake-beds. This drained the marshes and formed the bottom-lands, as the river-beds of that period covered the whole of the present flood-plains from bluff to bluff. It was then that the bluffs which now bound these flood-plains received those touches from the hand of nature that gave them their peculiar steep and rounded appearance. Newer and more plastic, because less compactly bound and cemented together, the rains and floods easily molded them into those peculiar outlines which they have since preserved. The Missouri, during the closing centuries of the Lacustrine age, must have been from five to thirty miles in breadth, forming a stream which for size and majesty rivaled the Amazon. The Platte,

the Niobrara, and the Republican covered their respective flood-plains in the same way. In the smaller streams of the State, those that originated within or near the Lacustrine deposits, such as the Elkhorn, Loup, Bow, Blue, and the Nemahas, we see the same general form of flood-plain as on the larger rivers, and no doubt their entire bottoms were also covered with water during this period. Hayden, in his first reports, has already expressed the same opinion as to the original size of these rivers. Only a few geologists will dissent from this view. The gradually melting glaciers, which had been accumulating for so many ages at the sources of these great rivers, the vast floods of water caused by the necessarily moist climate and heavy rains, the present forms and materials of the river-bottoms, are some of the causes which in my opinion would operate to produce such vast volumes of water.

The changes of level were not all upward during this age. The terraces along the Missouri, Platte, and Republican indicate that there were long periods when this portion of the continent was stationary. Once, at least, the movement was downward. Along the bluffs in the Republican Valley, at a depth varying from ten to thirty feet from the top, there is a line or streak of the Loess mingled with organic matter. It is, in fact, an old bed, where vegetation must have flourished for a long period. It can be traced from Orleans upward in places for seventy-five miles. It indicates that after this bed had, as dry land, sustained a growth of vegetation, an oscillation of level depressed it sufficiently to receive a great accumulation of Loess materials on top of it. I have found traces of this movement in many other portions of the State.

Length of the Loess age.

The bases for speculation concerning the length of the Loess age are of course uncertain, yet an approximate estimate may perhaps be made by comparison with the present deposits of the Missouri. The great lakes of the Loess age extended, with few interruptions, almost to the Gulf, and some of them covered an area of at least 75,000 square miles. Now, were all the sediment which is at present brought down the Missouri spread over such a vast area, the thickness of the deposit would be less than one-sixteenth of an inch. Probably the yearly accumulations of sediment during the Loess age amounted to that much, owing to the then greater volume of the Missouri and the aids to erosion from the greater prevalence of ice near its sources. In many places along the Missouri there are small lakes, formed from the old river-bed, where there has been a cut-off. Even where these little lakes receive the overflow of the river each year, it often requires at least a century to fill them up, even when aided by the sands which the winds waft into them. I have attempted to measure the sediment left by the river in these lakes, which are seldom half a mile in breadth, and it rarely amounted to half an inch in a season. The winds are a much more efficient agent for filling up small, narrow lakes, but in Loess times, where there were such immense bodies of fresh water, their effects could only have been appreciable along the sandy shore-lines. The highest bluffs represent the original level of the Loess deposits before the tremendous denuding agencies which removed so much of their materials had done their work. Now, in places these sediments are even yet 200 or more feet in thickness, so that it would be safe to estimate the average thickness of the original deposit at 100 feet. A yearly increase of one-sixteenth of an inch in thickness, would at this rate have required 19,200 years to form these deposits. This I consider a low estimate for the length of the Loess age.

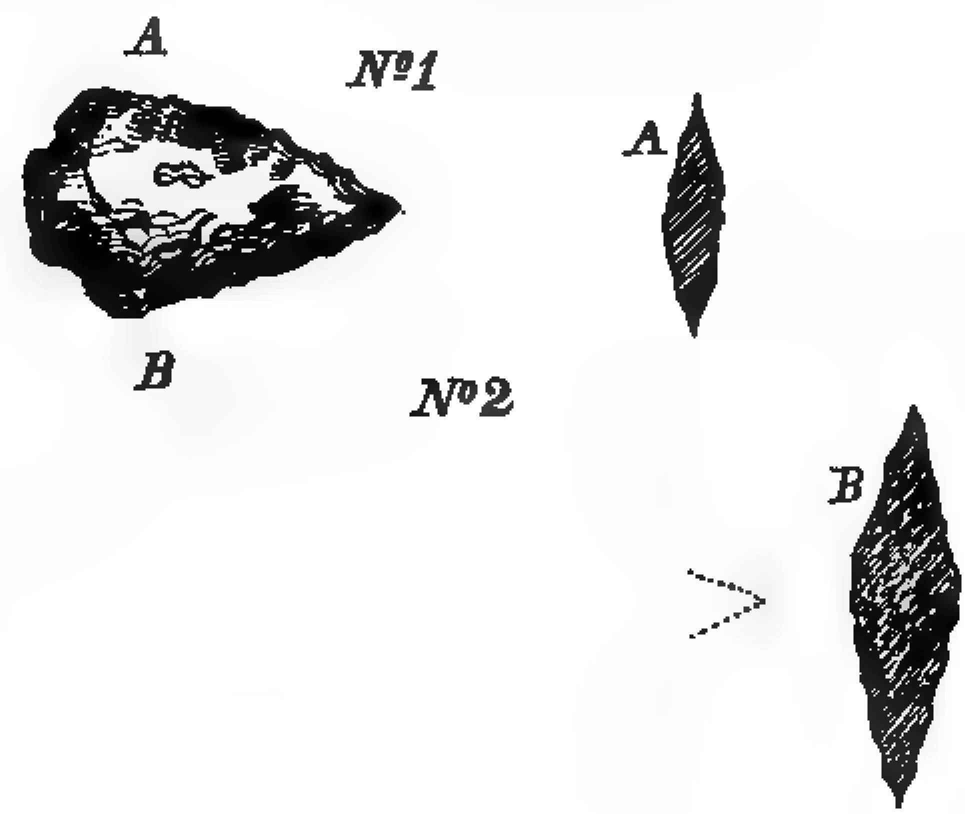
Life of the Loess age.

At the close of this article will be found a list of the land and fresh-water shells that I have found and identified in the Loess deposits. It will be seen that the list of land shells is quite large. These, no doubt, were brought into this old lake during flood-time. I have occasionally found large numbers of these shells where drift-wood had evidently lodged and decayed. The fresh-water and land shells are mainly such as are still to be found in the same region, the exceptions being the prevalence of a large number of southern forms at one horizon of these deposits. As will be seen, the species belong to quite a large number of genera.

Occasionally I have found the teeth and a stray bone of fish, but have not been able to identify any species. The remains of rabbits, gophers, otters, beavers, squirrels, deer, elk, and buffalo, are frequently found. Through the entire extent of these deposits are many remains of mastodons and elephants, whose last vigorous life, as Newberry remarks, expired in high northern latitudes. Lancaster County is specially rich in these proboscidian remains. They are frequently found in this deposit in digging wells. In Lincoln they have been found in at least twenty wells that have been dug in and around the city. This town is near what appears to have been the western shore-line of the Missouri lake of the period. Between it and the Blue River, at Crete, there is a high divide covered by Drift materials. These huge animals no doubt often here came down to the shore to drink, and playing in the water became mired in the mud. One tusk found in a well on P street, east of Twelfth, must have been at least eleven feet long when entire. It was so far decayed that it fell to pieces on exposure.

For years I have been closely watching for human remains in the Loess deposits. Five years ago, three miles east of Sioux City, Iowa, in a railroad-cut I found a small arrow-head in these deposits. I was looking for mollusks, and was digging after them with a large knife when I struck something hard, and, laying it bare, to my great surprise and joy found it to be an arrow-head. So far as I knew, this was the first mark that had yet been discovered of the presence of man during this age. From that time onward I have seized every opportunity for exploring these deposits for human remains. The same year I found some flint chips in the bluffs back of Jackson, in Dakota County, but it was not absolutely clear that these were of human origin. My next find was about two and a half miles southeast of Omaha, in a railroad-cut, where I found a large coarse arrow or spear head. This last was found two years ago. It was found twenty feet below the top of the Loess, and at least six inches from the edge of the cut, so that it could not have slid into that place. The first found was fifteen feet below the top of the deposit. Figure No. 1 is the arrow-head found east of Sioux City, and No. 2 found southeast of Omaha. It appears, then, that some old races lived around the shores of this ancient lake and paddled their canoes over its waters, and accidentally dropped their arrows in its waters or let them fly at a passing water-fowl. It is possible also that these arrows came into this old lake by drift-wood. I once found an arrow sticking in a log that came down the Missouri, and if it had continued on to the Gulf it might have been unearthed in the far-off future, when that portion of the continent at the mouth of the Mississippi had become dry land. Thirteen inches above the point where the last-named arrow was found, and within three inches of being on a line with it, in undisturbed Loess, there was a lumbar vertebra of an elephant (*Elephas*

americanus). Unfortunately this vertebra partially fell to pieces on exposure. It appears clear from this conjunction of a human relic and proboscidian remains that man here as well as in Europe was the cotemporary of the elephant in at least a portion of the Missouri Valley.



Arrows found in the Loess.

No. 1. Found three miles east of Sioux City, Iowa, fifteen feet below the surface.

No. 2. Found two miles and a half southeast of Omaha, Nebr., twenty feet below the surface and beneath a vertebra of an elephant.

The climate probably varied considerably during the progress of this age. What inclines me to that view is the fact that about the middle horizon an unusually large number of southern species of mollusks are found. This indeed is not conclusive, as this region is at this time remarkable for the presence of southern forms of insects and fresh-water mollusks.* Yet it appears to me that the unusual number of southern forms at this horizon of the Loess must indicate some modification of climate at that period. It may have been only on the eastern shore of this great lake, and caused by the even temperature which so large a body of fresh water produces on the side toward which the prevailing winds from the lake blow. We have such a phenomenon at the present day on the east shore of Lake Michigan. The Mississippi Valley is by its contour eminently favorable to the emigration northward of southern species.

These Loess deposits, which have done so much to enrich Nebraska, have received profound attention and study from some of the ablest geologists. But in more than one-half of the counties of the State they have not yet been investigated. Much to be discovered must yet remain in them. Though myself long engaged in their investigation, I rarely examine a new section in a well, ravine, or railroad-cut without finding something new.

* Hayden's Report for 1870, p. 467.

ALLUVIUM.

Next to the Loess deposits, in an economical point of view, the Alluvium formations are the most important. The valleys and flood-plains of the rivers and smaller streams, where these deposits are found, are a prominent feature of the surface geology of the State. All the rivers of the interior, such as the Platte, the Republican, the Niobrara, the Bow, the Elkhorn, the Blues, the Nemahas, and their tributaries, have broad bottoms, in the center or on one side of which the streams have their beds. The width of these bottoms seems to be dependent on the character of the underlying rock-formation. Where this is soft or yielding the bottoms are broad, but where it is hard and compact they contract. This is, no doubt, one reason why the bottoms on the middle or upper courses of some of the rivers are wider than farther down.* These broad bottoms, as we have already seen, represent the ancient river-beds toward the close of the Lacustrine age. It required many ages to drain this mighty ancient lake-bed; and when the present rivers were first outlined, the greater part of it was yet a vast swamp or bog. But, gradually, as the continent rose to a higher level, the rivers cut deeper and deeper, filling the whole flood-plain from bluff to bluff. Not until the drainage of this region was completed and the continent had reached nearly its present level was the volume of water so much diminished that the rivers contracted their currents and cut new beds somewhere through the present bottoms. The terraces, which are so numerous along many of the river-bottoms, indicate the slowness with which the land assumed its present form. They mark those stages of elevation when the land was stationary. The upper terraces were dry bottom when all the rest of the valley was yet a river-bed. It is probable that some of these bottoms were excavated during sub-glacial times, and afterward were filled up with *débris* when the continent had reached its lowest level. The great depth of sand and mud at the bottom of the Missouri, being from forty to one hundred feet below low water along the Nebraska line before solid rock is reached, indicates an elevation of this region, when this was accomplished, far greater than it reached at any period during Loess times. When this great lake commenced to be drained the waters naturally took the direction and place of least resistance, which was the original bed of the river. If the Rocky Mountain system continues to rise, as it is believed to be doing, at the rate of a few feet to the century, although degradation may be equal to elevation, a time must come in the distant future when the Missouri will again roll over solid rock at its bottom.

As typical of the river-bottoms, let us look at the formation of the Platte Valley. The general direction of this great highway from the mountains to the Missouri is from west to east. This valley is from three to fifteen miles wide in Nebraska, and over five hundred miles long. All the materials that once filled up this trough, from the top of the highest hills on each side, have been, since the present rivers were outlined toward the close of the Lacustrine age, transported by the agency of water to the Missouri and the Gulf.† Here, then, are several thousand miles in area of surface entirely removed by denudation. Now the Platte comprises only a fraction of the river-bottoms of Nebraska. The Republican alone for two hundred miles has a bottom ranging from three to eight miles in breadth. The combined length of the main bottoms of the Blues, Elkhorns, and the Loups would be over a thou-

* See on this subject Hayden's Report for 1870.
† Hayden's Report for 1870.

sand miles, and their breadth ranges from one to ten miles. The Mahas and the Bows, and portions of the Niobrara, also add a great deal to the area of bottom-lands. All these rivers have numerous tributaries, which have valleys in size proportionate to the main rivers, and these more than double the areas of bottom-land. The Missouri has, also, in some counties, like Dakota and Burt, contributed large areas of bottom-land to the soil of the State. These Missouri bottoms in Nebraska are exceptionally high, so that few of them have been overflowed since the settlement of the country. The one element of uncertainty about them is, when located near the river the danger of being gradually washed away by the undermining action of the water. Sometimes during flood-time, when the current sweeps the bank, it is so insidiously undermined that, for several rods in length and many feet in breadth, it tumbles into the river. This cutting of the river is greatest when it commences to fall. Where the bank is removed on one side it generally is built up on the other. The old town of Omadi, in Dakota County, is an instance of this kind. So rapidly did the river cut into the bank that many of the houses could not be removed, and fell victims to the flood. The river cut far enough to the west of the old site to leave it and its own bed, after being blown full of sand, to be grown up into a forest of cottonwood.

When now we bring into our estimate all the river-bottoms of Nebraska, and the tributaries of these rivers, and reflect that all these valleys were formed in the same way, within comparatively modern geological times, the forces which water-agencies brought into play almost appall the mind by their very immensity. So well are these bottom-lands distributed that the emigrants can, in most of the counties of the State, choose between them and the uplands for their future home. In some of the few counties, like Fillmore, where bottom-lands are far apart, there are many small, modern, dried-up lake-beds, whose soil is closely allied to that of the valleys. Not unfrequently is the choice made of portions of each, on the supposition that the bottom-lands are best adapted for the growth of large crops of grasses. But all the years of experience in cultivating uplands and bottoms in Nebraska leave the question of the superiority of the one over the other undecided. Both have their advocates. The seasons as well as the location have much to do with the question. Some bottom-lands are high and dry, while others are lower and contain so much alumina that in wet seasons they are difficult to work. On such lands, too, a wet spring interferes somewhat with early planting and sowing. All the uplands, too, which have a Loess origin, seem to produce cultivated grass as luxuriantly as the richest bottoms, especially where there is deep cultivation on old breaking. Again, most of the bottom-lands are so mingled with Loess materials, and their drainage is so good that the cereal grains and fruits are as productive on them as on the high lands. The bottom-lands are, however, the richest in organic matter. The following analyses of these soils will give a better idea of their chemical and physical character. The samples were taken from what are believed to be average soils. The first is from the Elkhorn, the second from the Platte, the third from the Republican, and the fourth from the Blue River. The fifth is from an exceptionally wet and sticky soil, about two miles southeast of Dakota City.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Insoluble (siliceous) matter	63.07	63.70	63.01	62.99	61.03
Ferric oxide	2.85	2.25	2.40	2.47	2.82
Alumina	8.41	7.76	8.36	8.08	10.52
Lime, carbonate	7.08	7.99	8.01	7.85	7.09
Lime, phosphate	.90	.85	.99	.94	.98
Magnesia, carbonate	1.41	1.45	1.39	1.40	1.38
Potash	.50	.54	.61	.67	.63
Soda	.49	.52	.54	.58	.57
Sulphuric acid	.79	.70	.71	.79	.60
Organic matter	14.00	13.45	13.01	13.27	13.40
Loss in analysis	50	.79	.97	.96	.98
	100.00	100.00	100.00	100.00	100.00

It is well known that many soils vary a great deal in chemical properties that are taken only a few feet apart, and therefore analyses often fail to give a correct idea of their true character. But from the above analyses, taken from widely distant localities, it is at least evident that chemically, alluvium differs from the Loess deposits, principally in having more organic matter and alumina, and less silica. The depth of the alluvium varies greatly. Occasionally sand and drift materials predominate in the river-bottoms, especially in the subsoil; sometimes the alluvium is of unknown depth, and again in a few feet the drift pebbles and sand of the subsoil are struck. This is especially the case in some of the western valleys which were worn down to the drift, and were not again subsequently filled up, though such cases are not often met with. There must have been a period of longer or shorter duration, when the bottoms were in the condition of swamps and bogs; and during this period the greater part of that organic matter, which is a distinguishing feature of these lands, accumulated in the surface-soil. It would be easy to select isolated spots, where the soil has forty per cent. of organic matter; where, in fact, it is composed of semi-peat. When we reflect that this black soil is often twenty feet thick, it is apparent that the period of its formation must have been exceedingly long. There are still some few localities where that formative condition has been perpetuated to the present time—as, for example, the bogs that are yet met with at the headwaters of the Elkhorn and the Logan, along the Elk Creek, on the Dakota bottom, and on Stinking River, one of the tributaries of the Republican. In fact, along these tributaries all the intermediate stages from perfectly dry bottom to a bog can yet be found. But, so much has the volume of water been lessened in all the rivers of Nebraska through the influence of geological causes, that there are few places where now, even in flood-time, they overflow their banks. A curious phenomenon, illustrating through what changes of level and other conditions these river-bottoms have passed, before reaching their present form, is the occurrence at various depths, of from ten to fifty feet, of great masses of timber in a semi-decayed condition. One such deposit on the Blue River bottom, near the mouth of Turkey Creek, successfully interrupted the digging of a well. So many thicknesses of logs occurred that it was found best to abandon the work already done for a new place. I have frequently observed trees, with trunks twenty to sixty feet long, sticking out from under the banks of the Missouri, where the soil had been freshly removed. It is possible that this timber accumulated in these places during the period when the rivers yet covered their entire bottoms, and when numberless trees must have been carried down during flood-time, and either stranded on the ancient sand-bars and mud-banks, or sunk to rise no

more in the deeper pools and eddies which were rapidly filled up. The species, so far as I have yet been able to determine, from an examination of the half-decayed wood, are the same as yet grow in this region. They are principally cottonwood, elm, cedar, maple, and walnut.

THE SAND-HILLS.

The sand-hills are an often-mentioned portion of Nebraska. They are found in certain sections of the western portion of the State. South of the Platte Valley they run parallel with the river, and are from one-half to six miles in breadth. A few are also found on the tributaries of the Republican. Occasionally slightly sandy districts are found as far east as the Elkhorn, but they rarely approach even a small hill in magnitude. North of the Platte, from about the mouth of the Calamus on to the Niobrara, they cover much larger areas. They are also found over a limited area north of the Niobrara. Hayden (Report for 1870, p. 108) estimates the area of the sand-hills at about 20,000 square miles. From exploring the same region, I should not estimate them as so extensive, unless the fact be kept in mind that they are not continuous over the whole region. They are indeed found all the way for 100 miles west from the mouth of Rapid River, but in many places from eight to twenty miles south of the Niobrara there are spots where the soil seemed to be a mixture of Drift and Loess, and of high fertility, as was indicated by the character and rankness of the vegetation. Sometimes these hills are comparatively barren, and then again they are fertile enough to sustain a scant covering of nutritious grasses; so that this region is by no means the utterly barren waste that it is sometimes represented to be. It has been a favorite range for buffalo, and still is for antelope and deer; and, judging from their condition, the conclusion would be natural that this region could be used for stock-raising. A great deal of the vegetation is peculiar to sandy districts. Some of the hills seem to have their loose sands held together by the *Yoca angustifolia*, which sends its roots down to a great depth. It probably marks a certain stage in their history. After this plant has compacted and given to the sands organic matter, the grasses come in and partially clothe the hills. The materials of these sand-hills are almost entirely sand, pebbles, and gravel, of varying degrees of fineness. The sand always predominates. Occasionally it is more or less modified by the presence of other materials, such as lime, potash, soda, alumina, and organic matter. These hills are in some places stationary, and so covered by vegetation that their true character is not suspected until closely examined. In other places again, especially in portions of the Loup and the Niobrara region, they are so loosely compacted that the wind is ever changing their form, and turning them into all kinds of fantastic shapes. The most common appearance is that of a plain, undulating, or hilly region, covered with conical hills of drifting sands. The smaller elevations frequently show striking resemblance to craters. One such curious hill I found south of the Calamus, where the crater-like basin seemed to be compacted at once, and grown over with a species of wire-grass.

Some eminent geologists have sought to account for these hills by the theory that the winds in the course of ages have blown the sand from the bars on the rivers until their accumulation caused these peculiar elevations. There are many difficulties in the way of this theory. East of Columbus no sand-hills are found, and it is hard to conceive how they should come to be limited to the western portion of the State if they were formed in this way. In some places at least the hills are

partly composed of large pebbles and stones that could not have been moved by the winds. This is especially the case in some of these hills south and east of Kenesaw, in Adams County. I suggest, as a provisional explanation, the probability that south of the Platte the lines of sand-hills show the track of a current in the old lake that produced the Loess deposits. It is well known that fine sediment is deposited in still water, but coarse materials, such as sand and pebbles, in the borders and in tracks of currents. As the whole country rises toward the west, the water here may have been very rapid, and the land in process of drying up when it was yet deep at lower levels. Both causes, the currents and the winds, may have co-operated to produce these deposits. I am also satisfied that in some localities the sand-hills are nothing more than modified Loess deposits. They are Loess deposits, with all the alumina, organic matter, and finest sands washed out of them. This at least seems to be the origin of some of the sand-hills on the Lower Loup, where they occupy a lower level than the Loess deposits. These two deposits so often shade into each other in the neighborhood of the sand-hills, rendering it impossible to tell where the one begins and the other ends, that the theory of their common origin best explains the phenomena of these formations. After the western portion of the Loess deposits first became dry land, water-agencies were yet so powerful, especially in flood-times, that much of it must have been remodified, and the coarser materials left to form sand-hills. On the other hand, the sand-hills on the Upper Loup and the Niobrara probably derived the bulk of their materials directly from Pliocene Tertiary deposits, which were mainly loosely-compacted sands. This old Pliocene lake was probably perpetuated here down through Loess times to the borders of our own era. Even yet lakelets are numerous over portions of this region, some of which are alkaline and others fresh-water. The latter can easily be distinguished from the former at sight, by the thick vegetation growing around their margins, of which the former have very little, and sometimes not a trace. It is at least evident that these fresh water lakes have had some common origin. Their fauna would prove it. The same species of fish and fresh-water mollusks are found in most of the large ones, even where there is no perceptible present outlet.

Although opposed to the views of eminent scientists, I have no doubt that many of these hills are capable of cultivation and some day will be cultivated. Not, indeed, until the rich lands that border them are improved. But when better lands become scarce and costly, advances will gradually be made on the sand-hills. Already it has been proved that they produce sweet-potatoes and other root-crops equal at least to the New Jersey sands. The rich marl-beds in their vicinity will supply an inexhaustible source for fertilizing them.

Much as has been done by Hayden and others in exploring these sand-hills, still much more remains for the geologist before all the causes that produced them are thoroughly understood.

ALKALI LANDS.

Every one in Nebraska will sooner or later hear of the so-called alkali lands. They are not confined to any one geological formation, but are found sometimes on the Drift, Alluvium, or the Loess. They increase in number from the eastern to the western portions of the State. Yet one-half of the counties of the State do not have any such lands, and often there are only a few in a township or county. Where they have been closely

examined they are found to vary a great deal in chemical constituents. Generally, however, the alkali is largely composed of soda compounds, with an occasional excess of lime and magnesia or potash. The following analysis of these soils shows how variable they are. The first is taken from the Platte bottom, south of North Platte; the second from near old Fort Kearney, and the third two miles west of Lincoln.

Insoluble (siliceous) matter	74.00	73.10	73.90
Ferric oxide	3.80	3.73	3.69
Alumina	2.08	2.29	2.10
Lime, carbonate	6.01	4.29	3.90
Lime, phosphate	1.70	1.40	1.49
Magnesia, carbonate	1.89	1.29	1.47
Potash	1.68	1.80	3.69
Soda, carbonate and bicarbonate	5.17	7.33	4.91
Sodium, sulphate	.70	.89	.89
Moisture	.99	.98	.98
Organic matter	1.20	2.10	2.10
Loss in analysis	.78	.80	.88
	100.00	100.00	100.00

The specimens for analysis were not taken from soils crusted over with alkaline matter, but from spots where the ground was covered with a sparse vegetation.

Many of the alkali lands seem to have originated from an accumulation of water in low places, where there is an excess of alumina in the soil or subsoil. The escape of the water by evaporation left the saline matter behind, and, in the case of salt (sodium chloride), which all waters are known to contain in at least minute quantities, the chlorine, by chemical reactions, separated from the sodium; which latter, uniting immediately with oxygen and carbonic acid, formed the soda compounds.

These alkali spots are often successfully cultivated. The first steps toward their renovation must be drainage and deep cultivation. The next step is the consumption of the excess of alkali, which can be effected by crops of the cereal grains in wet seasons. In such seasons these alkali lands, if deeply cultivated, often produce splendid crops of grain. Wheat is especially a great consumer of the alkalies; and these being partly removed in this way, and the remaining excess mingled with the deeply-cultivated soil, renders it, in many instances, in a few years capable of being used for the other ordinary crops of Nebraska. Treated in this way, these alkali lands often become the most valuable portions of the farm. There are comparatively few alkali lands in the State that cannot be reclaimed in this way.

THE BAD LANDS.

The bad lands do not really belong to the surface-deposits, as they constitute a peculiar formation, where most of the soil capable of being cultivated has been removed by denudation. As they, however, comprise nearly all that there is of the surface in a part of the northwest corner of the State, they deserve mention in this place. They are mostly found between Spoon Hill Creek and the Niobrara River, and they extend down from the White River in Dakota Territory. They belong to what Hayden calls the White River group of Tertiary rocks. They are believed to be of Miocene age. This region has long been known as the bad lands—*mauvaises terres*, or, in the Dakota language, *ma-koo-si-tcha*, which means a difficult country to travel, because the surface is very broken, and there is little, if any, good water, wood, or game.* The

* Hayden United States Geological Survey, 1870.

materials of the deposits are white and yellowish indurated clays, sands, marls, and occasional thin beds of lime and sand stones. When going through these bad lands, I observed these lime and sand stones to appear and disappear in the most unexpected manner, indicating great variety in the conditions under which they were formed. The world is indebted to Hayden for investigating and making known these wonderful beds. His descriptions of them are correct in every particular; and yet it is hard to realize their grandeur and uniqueness without personally visiting them. This, at least, was the case with myself. The geologist never tires of investigating these deposits and their curious remains. The almost vertical sections of variously-colored rock have been chiseled by water agencies into unique forms. Indeed, viewed from a short distance they remind the explorer of one of those old cities which only exhibit their ruins as reminders of their ancient greatness. Among these grand desolations the weird, wild old stories of witchery appear plausible and possible. It is in the deep cañons at the foot of stair-like projections that the earliest of those wonderful fossil treasures are found which have done so much to revolutionize our notions of the progress of life and of Tertiary times. In the lower beds of this deposit are found remains of *Rhinoceri* and *Hyppopotami*, which were river-horses much like the *Hyppopotami* of modern times. Higher up in the deposits are found countless numbers of turtles, mingled with the remains of land-animals. I was especially amazed at the number of these turtles in a light reddish-colored marl-bed. They seemed in a few localities to constitute almost the entire deposit. Among these animal-remains none are more curious than the *Oreontidæ*, which Leidy calls ruminating hogs, because their cutting teeth and canines and their feet were like those of the swine family, while their molars were patterned after those of the deer, and the upper portions of the head much like that of the camels. According to Hayden, they existed in great numbers of species and individuals, and congregated in great herds, like the buffaloes in their palmy days. Here also are found the remains of many species of horses and a few camels, a beaver, &c. The vast numbers of these animals were kept within bounds by gigantic carniverous animals, such as saber-toothed tigers, *Hyaenodons*, foxes, wolves, &c.

Agriculture in such a region as this, where often nothing is now growing is, of course, out of the question. Whether there ever will be such an increased rain-fall as to start vegetation in this region and make its surface capable of cultivation, is a problem of the future. Regions as rough have been cultivated by hand. Here some of the deposits, like the marls, possess the elements of fertility in a high degree, but moisture is entirely lacking. Though this region is so unattractive to the utilitarian, I doubt whether any other equal area of Nebraska will be of more benefit to mankind, simply because here we have outlined so marvelously the old life of Miocene times, and it must ever be a stimulus to geological studies, and those grand results which scientific culture produces. No novel can be as interesting to a thoughtful mind as Hayden's descriptions of these bad lands and their animal remains.

FUEL FROM THE SURFACE-DEPOSITS.

It is not yet absolutely settled how much dependence can be placed on the coal-supplies of the Carboniferous, Cretaceous, and Tertiary deposits, in each of which thin beds have been found and worked to a limited extent. Hayden and Meek incline to the opinion that no beds of coal thick enough and of sufficiently good quality to be profitably

worked will be found in the State. (Hayden's Report for 1870, p. 134, &c.) There is, however, no question about the great quantity of peat in Nebraska. Hayden mentions many localities where it is found. (Report for 1867, 1868, and 1869.) It is also found on the tributaries and headwaters of the Logan, the Elkhorn, the Blue, and on Stinking River, and other tributaries of the Republican. One peat-bog on the Logan (township 28 north, 1 and 2 east) is five or six miles in length and of variable breadth. I could find no bottom to this bog with a fifteen-foot pole. This peat I personally tested and found to be of excellent quality. In fact, nearly all the peat that I have tested in the State is fully up to the average in quality. A singularly good article is found at Pittsburgh, on the Blue River, where the deposit is also quite extensive. Among the animal-remains submitted to me for examination from this bed was a molar tooth of the gigantic beaver (*Castor ohioensis*), proving that this animal existed in Nebraska in times geologically recent. The most of the peat-beds that I have examined seem to have been formed in lakelets that gradually became bogs by an accumulation of vegetable matter derived from coarse grasses, sedges, rushes, polygonums, duck-weeds, pond-weeds, arrow-weed, &c., lilies, &c. Sphagnum, which seems to form the mass of organic matter in peat-bogs of granitic and siliceous districts, only occurs in Nebraska in a bog near Curlew, in Cedar County, and one or two other places in the same region. At least I found it nowhere else. Many of these peat-bogs are now so far advanced as to be dry enough to be wagoned over in midsummer, but through the middle of which a stream of water is still flowing. Others have no visible outlet, but retain the water poured into them, when the spring and June rains fall, during the remainder of the year, and thus supply the conditions necessary for the peculiar vegetation of such formations. Sometimes, too, depressions in the surface where peat is forming are supplied with moisture from ever-flowing springs. The beginnings of many of these peat-beds date back at least to the close of the Loess age, so that sufficient time has elapsed for the accumulation of great quantities of this material. Peat can be cheaply taken out of a bog with a spade, and laid up like cord-wood under cover to dry, when it is ready for use. The objections to using it thus prepared is its liability to crumble. Unfortunately, to prepare it by molding and pressing requires some capital for apparatus, and this is one reason why these beds have not yet been worked. In some places, too, wood-fuel is yet cheap, and in others coal from abroad is easily obtained, and these causes have also operated to delay the use of peat for fuel. But such treasures cannot remain unused forever. Eventually this peat must be utilized, and, if it is cheaply furnished, as it can be, the State will be supplied for a long time from its own territory for manufacturing purposes and domestic use with all the fuel needed. (For an able discussion of peat in Nebraska, see Hayden's Final Report of Geological Survey of Nebraska, p. 69.)

WATER RESOURCES OF NEBRASKA.

Running streams are an evidence of the degree of moisture in a region, and with these Nebraska is well supplied. Any good map of the State will show numerous rivulets flowing into the larger creeks and rivers. But no map that I have yet seen does or can do full justice to the numberless small streams that are found in the State. Having traveled, as a naturalist and explorer, over a large part of Northern Nebraska, I frequently came across small streams with beautiful bottoms, where even the published plats of the public surveys failed to indicate them. In

fact, there are large areas of the State where running water can be found on every section, and often on every quarter-section of land. Where such water resources do not exist, it can easily be obtained by digging or boring to a certain depth. In the Loess deposits water is frequently found at a depth of from fifteen to forty-five feet. If this proves a failure, as it occasionally does, water can be obtained beneath, in the Drift; or, where this is absent, when the underlying rocks are reached. At the bottom of the Loess deposits there is generally a layer of sand or gravel, which is a great reservoir of water, and from which it flows in unlimited quantities. In some of the counties drained by the Blue Rivers and their tributaries, but rarely east of them, where the Loess deposits are very thick, water is not found until this stratum of sand and gravel is struck, at a depth of from sixty to one hundred and twenty feet. I have known of only a few instances where the underlying rocks had to be penetrated to secure permanent water. This underlying bed of sand and gravel is, as before observed, probably Drift, and exists, at some depth, over the greater part of the State. An interesting phenomenon connected with the Platte and Republican Rivers is the drainage of a portion of the waters of the former into the latter. The Platte flows eastward, at a considerably higher level than the Republican, and between the two rivers there is a large area of Loess, underlaid by Drift, sand and gravel, which in many places is continuous between the two rivers. Through this Drift, sand and gravel the waters of the Platte, where they run over it, flow into the Republican. The two rivers are, in the main, parallel, and, at the meridian of Kearney Junction, are only forty miles apart. In traveling along the Republican for a hundred miles, from Orleans westward, and by wading in the river for miles at a time, I observed such a quantity of water trickling through these sands near the water's edge, in hundreds of places, that it could not possibly all have come from the superficial deposits. It was during the dry season (August) of 1874 that I made these examinations. Occasionally, where this underlying bed of sand and gravel lies on clay or rock, subterranean currents are formed.

At a distance from running streams it is found, by experience, to be cheapest and best to supply water to stock and for domestic use by sinking a shaft to the Drift, where water is found, and working the pump by a wind-mill. One such at Ball's ranch, on the road between Kearney and Orleans, had the tank kept full by a windmill, and furnished, as I was informed at the place, water for four hundred cattle and other stock, the traveling public, and for domestic use. The well here was one hundred feet deep, ninety of which passed through Loess deposits. Half a dozen small farmers often might unite to dig such a well, and to supply it with a windmill, near the intersection of their lands. This would be especially advantageous in the region between these two rivers, west of the meridian of Kearney, where the subsoil is Loess, and very thick; where running streams are few, and where wells must be sunken deep to reach permanent water.

Chemical analyses show that the waters of the State, excepting the semi-alkaline ponds in some sections, is fully equal to the average in purity. The most common foreign ingredient is lime carbonate. I have frequently examined wells whose waters were charged with being impure, and in every instance found that the impurity was caused by the presence of organic matter that had been permitted to be washed in from the surface. A correction of this defect soon purified the well.

An interesting meteorological fact, having an important bearing on geological causes, is the increase of rain-fall all over the State, as civili-

zation advances westward. As early as the summer of 1865, I examined the region at the headwaters of the Logan, Elkhorn, and Bow Rivers, where I found many small ancient creek-bottoms, with stream-beds in the center, or nearer one side, all grown over with a thick sod of grass and weeds, and where the water had not flowed for ages. To be sure of this conclusion, I dug down, at convenient places, to ascertain the condition of the subsoil. In almost every instance I found more or less shells of fresh-water mollusks, so decayed that on the least exposure they would crumble to pieces. They all belonged to the genus *Unio* or *Anadonta*, the former seemingly being most abundant, but this probably resulted from the greater fragility of the latter. I failed to identify any species. Many of these localities I had marked. Already in 1871 many of these old streams commenced again to flow, and since then many more have become supplied with apparently permanent water. Many springs of water, too, are bursting out along bluffs where nothing of the kind was known before. It is probable that the great amount of land broken up and cultivated absorbs more of the falling rains than could have been taken in by the hard prairie. Let any one carefully watch a slope, one-half of which is plowed deeply, and the other half yet virgin prairie, during a heavy rain; the former will absorb all the water that falls, while it runs off the latter in currents. The constant evaporation of this increased water-supply must, in the nature of the case, produce more vapor in the atmosphere. In my opinion, however, we may account for it. There is little room to doubt that the atmosphere is becoming more moist or the rain-fall is increasing, or both, all over Eastern and probably Western Nebraska. The great change constantly going on in the flora of the State points to the same conclusion. The grasses especially and the sedges characteristic of dry regions are rapidly retreating, and in many places disappearing altogether, while others, that are more peculiar to moister regions, are taking their places. Hayden, from a most careful study of a partially different class of facts, long since came to a similar conclusion. (See his report for 1870, p. 455, &c.)

TIMBER IN MODERN GEOLOGICAL TIMES.

It is natural to suppose from well-known natural causes that when the Loess age was drawing to a close, and the lower portions of the area covered by these deposits was yet in the condition of a bog, the climate was much more favorable than the present for the growth of timber. Rainfall and moisture in the atmosphere must then have been much more abundant. In July, 1868, while walking along the edge of one of the Logan peat-bogs in Cedar County, my jacob-staff struck some hard body in the peat. Examining it more closely I found a log buried in the peat at least sixty feet in length. Following up this discovery with a careful search, I found in this and other bogs a great many buried logs of various length and thickness. Most of them were found where there was no existing timber within twenty miles, and from which they could not have floated in flood-times. I regret that I had no means of extricating some of those logs, and ascertaining the species to which they belonged. That would no doubt have thrown much light on the changes that have taken place since they were buried in the bog. But they evidently grew on the shores or banks, and after falling into the bogs they were protected against decay by the well-known antiseptic properties of peaty waters. Another fact that shows the greater prevalence of timber within geologically recent times is the remnants of old pine-forests yet buried in the ground. In the summer of 1868, when traveling along

and near the Niobrara, roots of pine trees were often found sticking in the ground, more than fifty miles south and east of the present forests of this timber. Often did these old roots furnish me with the materials of a camp fire. At no very remote period pine forests must have flourished down to the mouth of the Niobrara. Many other facts, of a similar character, seem to leave no room to doubt that in geologically recent times far more extensive forests prevailed all over Nebraska than those which now occupy the ground. What caused their disappearance can, perhaps, not be certainly determined. Some geologists hold that the increasing dryness of the climate caused the disappearance of any old forests that might have existed. But might not the converse of this also have been true here, as well as elsewhere, namely, that the destruction of forests inaugurated the dry climate that prevailed when this territory was first explored? It is at least conceivable that the primitive forest received its death-blow in a dry summer by fire, through the vandal acts of Indians in pursuit of game or for purposes of war. What suggested this theory as a possible explanation of the disappearance of forests on this territory, was the finding of the pine-roots before referred to, and often, when partially buried, showing marks of fire from carbonized ends, and in localities so sandy, and where vegetation was so scant, that an ordinary prairie-fire was out of the question. An old tradition, that I once heard from the Omaha Indians, points to the same conclusion.

It is wonderful how nature here responds to the effort of man for reclothing this territory with timber. Man thus becomes an efficient agent for the production of geological changes. As prairie-fires are repressed and trees are planted by the million, the climate must be still further ameliorated. When once there are groves of timber on every section or quarter-section of land in the State, an approach will be made to some of the best physical conditions of Tertiary times. The people of this new State have a wonderful inheritance of wealth, beauty, and power in their fine climate and their rich lands, and as they become conscious of this they will more and more lend a helping hand to the processes of nature for the development and utilization of the material wealth of Nebraska.

MOLLUSKS IN THE LACUSTRINE DEPOSITS.

The following list of land and fresh-water shells comprise all that I have thus far identified, in whole or in part, from the Lacustrine deposits. Nearly all are extremely fragile. The Hyalinas, Pupas, and some of the Helices long eluded my efforts at identifying them. I finally marked the localities where found until the ground was frozen, when they were cut out with a knife. They were then identified by making thin sections with a sharp knife. Many of these mollusks, after being placed for a while in my cabinet, fell to pieces. For this reason, I have no specimens to show of many species here given, and, therefore, only present this as a provisional list. Some well-preserved specimens appear to me to be new to science, but as I have not access to the descriptions of the new species discovered by Hayden, a bare list of which is given in Binney and Bland's Land and Fresh Water Shells, I will not venture to describe them, as that has probably already been done. The counties are indicated where the specimens were obtained, or where they were the most abundant:

Vitrina limpida Gould, Lancaster and Dixon Counties.

Hyalina nitida? Müller, Dixon County.

Hyalina arborea Say, Douglas and Dakota Counties.
Hyalina viridula Monke, all Eastern Nebraska.
Hyalina indentata Say, Otoe and Douglas Counties.
Hyalina limatula Ward, Douglas County.
Hyalina minuscula Binney, all Eastern Nebraska.
Hyalina binneyana ? Morse, Dixon and Cedar Counties.
Hyalina ferrea ? Morse, Dixon County.
Hyalina exigua Stimpson, Dixon and Cedar Counties.
Hyalina intertexta ? Binney, Douglas County.
Hyalina ligera Say, Otoe and Nemaha Counties.
Hyalina demissa ? Binney, Nemaha and Richardson Counties.
Hyalina fulva Dreparnaud, Dixon and Cedar Counties.
Hyalina lasmodon Phillips, Nemaha and Otoe Counties.
Hyalina interna Say, Nemaha and Otoe Counties.
Hyalina significans Bland, Nemaha and Otoe Counties.
Hyalina lineata ? Say, Douglas and Otoe Counties.
Macrocyclis concava Say, Douglas and Otoe Counties.
Helix solitaria Say, Otoe and Burt Counties.
Helix strigosa Gould, Otoe and Burt Counties.
Helix alternata Say, all Eastern Nebraska.
Helix cumberlandiana Lea, Middle Lacustrine in Nemaha and Otoe Counties.
Helix cooperi W. G. B., Douglas and Washington Counties.
Helix striatella Anthony, Dixon and Dakota Counties.
Helix labyrinthica Say, all Eastern Nebraska.
Helix hubbardi Brown, Middle Lacustrine in Nemaha County.
Helix auriformis Bland, Middle Lacustrine in Otoe County.
Helix tholus ? W. G. Binney, Middle Lacustrine in Douglas County.
Helix fastigans L. W. Say, Middle Lacustrine in Otoe County.
Helix Jacksonii ? Bland, Middle Lacustrine in Otoe County.
Helix hazardi ? Bland, Middle Lacustrine in Douglas County.
Helix dorfeuilliana Lea, Middle Lacustrine in Cass County.
Helix pustula ? Fer, Middle Lacustrine of Cass County.
Helix spinosa Lea, Middle Lacustrine of Harlan County.
Helix edgariana ? Lea, Middle Lacustrine of Richardson County.
Helix stenotrema Fer, Otoe and Cass Counties.
Helix hirsuta Say, Dixon and Cass Counties.
Helix monodon Rackett, all Eastern Nebraska.
Helix palliata Say, all Eastern Nebraska.
Helix abstricta ? Say, all Eastern Nebraska.
Helix appressa ? Say, Otoe and Nemaha Counties.
Helix inflecta Say, all Eastern Nebraska.
Helix tridentata ? all Eastern Nebraska.
Helix fallax Say, all Eastern Nebraska and Republican Valley.
Helix albolabris Say, Eastern Nebraska and Republican Valley.
Helix multilineata Say, all Eastern Nebraska.
Helix pennsylvanica Green, Douglas County.
Helix elevata Say, Eastern Nebraska and Republican Valley.
Helix exoleta Binney, Eastern Nebraska and Republican Valley.
Helix roemeri Pfeifer, Middle Lacustrine of Richardson County.
Helix thyroides Say, Eastern Nebraska and Republican Valley.
Helix clausa Say, Eastern Nebraska.
Helix jejuna ? Say, Richardson County.
Helix profunda Say, all Eastern Nebraska and Republican Valley.
Helix pulchella Müll., all Eastern Nebraska and Republican Valley.
Helix ———, Republican Valley

Helix ———, Otoe and Nemaha Counties.
Helix ———, Otoe and Nemaha Counties.
Helix ———, Otoe and Nemaha Counties.
Helix ———, Dakota and Dixon Counties.
Helix ———, Dakota and Dixon Counties.
Bulimulus dealbatus Say, Middle Lacustrine of Nemaha County.
Cionella subcylindrica Linn., Southeastern Nebraska.
Pupa muscorum ? Linn., Cedar County.
Pupa blandi Morse, Dixon, Dakota, and Burt Counties.
Pupa fallax Say, Dixon, Dakota, and Burt Counties.
Pupa armifera Say, all Eastern Nebraska.
Pupa corticaria Say, all Eastern Nebraska.
Succinea haydeni ? W. G. B., Republican Valley.
Succinea mooresiana Lea, Republican Valley.
Succinea avara, Lea, Republican Valley.
Succinea obliqua, Say, Dixon and Dakota Counties.
Succinea ———, Otoe and Nemaha Counties.
Zonites fuliginosa, Griff., Republican Valley.
Zonites lævigata ? Pfeiffer, Republican Valley.
Zonites inornata, Say, Cass and Otoe Counties.
Zonites gularis, Say, Southeastern Nebraska.
Carychium ? exiguum ? Say, Nemaha County.
Limnæa stagnalis ? Linn., Washington County.
Limnæa replexa Say, Dakota and Dixon Counties.
Limnæa palustris Müll., along Missouri Bluffs.
Physa gyrina Say, Dakota County.
Physa heterostropha Say, Douglas County.
Physa ———, Douglas County.
Physa ———, Douglas County.
Psulinus ———, Otoe County.
Planorbis glabratus Say, Otoe County.
Planorbis campanulatus Say, Dakota County.
Planorbis corpulentus ? Say, Dakota County.
Planorbis deflectus Say, Nemaha County.
Planorbis albus ? Müll., Dixon County.
Ancylus ———, Dakota, Harlan County.
Valvata tricarinata Say, Dixon County.
Valvata ——— Say, Otoe and Burt Counties.
Vivipara intertexta ? Say, Otoe County.
Vivipara subpurpurea ? Say, Otoe and Nemaha Counties.
Vivipara contectoides Binney, Nemaha County.
Melantho ponderosa Say, Washington County.
Melantho decisa Say, Burt County.
Amnicola perata ? Say, Washington County.
Amnicola lemnosa ? Say, Washington County.
Pomatiopsis lapidaria Say, Dakota County.
Helicina orbiculata Say, Nemaha County.
Angitrema armigera Say, Nemaha County.
Lithasia obovata Say, Richardson County.
Pleurocera undulatum ? Harlan County.
Pleurocera canaleculatum Say, Nemaha County.
Pleurocera elevatum Say, Otoe County.
Pleurocera labiatum ? Lea, Richardson County.
Pleurocera simplex ? Lea, Otoe County.
Goniobasis depygis Say, Richardson and Otoe Counties.
Goniobasis livescens ? Menke, Richardson County.

Goniobasis brevispira? Anthony, Otoe County.
Goniobasis semicarinata Say, Otoe County.
Anculosa costata Anthony, Richardson County.
Anculosa praerosa Say, Richardson County.
Anculosa? ——, Richardson County.
Unio ——, Cedar, Dakota, and Burt Counties.
Unio ——, Nemaha County.
Unio ——, Otoe and Cass Counties.
Anadonta ——, Washington County.
Anadonta ——, Republican Valley.

PALEONTOLOGY.

REPORT OF LEO LESQUEREUX.

COLUMBUS, OHIO, *March* 7, 1876.

DEAR SIR: I send you herewith, on the fossil floras of the western Territories, a record of the progress and discoveries in this section of the North American natural history, since the publication of the last annual report for 1873.

The memoir is divided into two parts. The first refers again to the evidence afforded by fossil plants to the age of the lignitic formations, and describes the species not yet known from former communications. The second critically reviews the Cretaceous flora of the Dakota group, and describes also, with figures, the new materials obtained from this remarkable formation. This revision was demanded not only by the important discoveries which have enriched this flora, but especially by the kind criticisms of European authors and the great interest with which the publication of the Cretaceous flora has been received by geologists.

Very respectfully, yours,

L. LESQUEREUX.

Prof. F. V. HAYDEN,
United States Geologist, Washington.

ON THE TERTIARY FLORA OF THE NORTH AMERICAN LIGNITIC, CONSIDERED AS EVIDENCE OF THE AGE OF THE FORMATION.

The purpose of this memoir, as indicated by the heading title, is to present, with more details, the evidence offered by the flora of the Lignitic Measures of the West, in regard to the geological age of their formation, which I consider as Tertiary. The reasons advanced in favor of this opinion in the two former annual reports of Dr. Hayden, and in a paper in the American Journal of Science and Arts,* are controverted by some geologists who consider the Lignitic as Cretaceous, denying to vegetable paleontology the authority of evidence in a question of this kind. Their arguments may be briefly exposed in the order in which I propose to examine and discuss their importance.

1st. Fossil plants are rarely found in the geological formations which are mostly marine; the vegetable remains are generally undeterminable fragments of leaves; they have been, as yet, scarcely studied in this country; the records of the fossil floras are nearly mere blanks.

2d. If even the fossil flora of the great Lignitic of the West had been widely studied, it could not afford any reliable evidence, on account of the impossibility of a conclusive comparison of its species. A comparison of the fossil plants of this continent with those of Europe can prove nothing in regard to identification of geological periods, for the reason that at the same epoch the floras of both continents may have been far different in their character, a necessary result of differences in their atmospheric circumstances of the same period of time.

3d. Even supposing that the evidence could be admitted, it is put at naught by the presence of cretaceous animal remains in strata within or above the lignitic formations, and animal remains must have priority for the determination of geological groups.

4th. The strata of the Lignitic conformably overlie the Cretaceous, and the nature of the compounds of these so-called different formations are similar.

5th. Stratigraphy and animal paleontology have forced the conclusion in regard to the cretaceous age of the western Lignitic, and geologists of high standing have, by their opinion, given full authority to this conclusion.

The text of the argumentation in favor of the cretaceous age of the Lignitic is here exposed in the fairest possible way. It could be said merely that the objections have been already considered and answered, but nobody would be satisfied or enlightened by this assertion. It is, therefore, advisable to reconsider the subject and to expose, instead of contradicting arguments, facts, which, corroborating former assertions, bring some new light upon the controverted question. For, in the two

*Annual Report of the United States Geological and Geographical Survey, &c., for the explorations of 1872, p. 318, &c. Same Report for explorations of 1873, p. 367. On the age of the lignitic formations of the Rocky Mountains, American Journal of Science and Arts, vol. vii, June, 1874.

past years, the researches in the vegetable paleontology of the Lignitic have greatly added to what was known of its domain when the former reports were published.

To consider the first objection—*that fossil plants are rarely found in the geological formations which are mostly marine; that the vegetable remains are mostly undeterminable fragments of leaves; that they have been as yet scarcely studied; and that the records of the fossil floras are mere blanks*—it will be necessary to open a while these so-called blank records of our North American geological floras and look over them a little.

We cannot boast, indeed, of a wide acquaintance with the fossil plants of the Silurian, for the good reason that they have been rarely looked for and studied. The formations of that epoch being mostly marine, their flora is represented by fucoidal remains, or plants which, originally of a soft texture, have generally been deformed and rendered undeterminable by maceration and compression. Prof. James Hall has, however, described some of those primitive vegetable forms, and his contributions to the vegetable paleontology of the Silurian have been acknowledged and honorably recorded by European authors. Of the twenty species of silurian plants described by Göppert in his Flora of the Formations of Transition, sixteen are credited to the authorship of Hall.

Besides the general instruction afforded by the representation of those plants of primitive ages, we find in them already, though uncertain their characters may be, an authority for the identification of silurian strata in far distant countries. It is the case, for example, with *Dictionema flabelliforme*, Hall, Eich., which identifies, by its abundant remains, the Lower Silurian of Norway and of Bohemia, &c., the Lingula flags of England, Ireland, and the strata of the same age, the Potsdam epoch of the United States and Canada.

As I have merely to consider the remains of land-plants, the whole silurian flora might be left out of notice as foreign to the subject. But even land-plants have their history, at least the first lines of it, written in those silurian formations, considered till now as a succession of marine deposits, as a time when our planet was surrounded by water, and when as yet there was no land exposed to view. Two years ago a few stems or branches were found in beds of hard clay of the Cincinnati group of the Silurian, near Lebanon, Ohio. They were, after examination, considered as remains of land-plants, and as representing upon their surface the impression of scars as a species of *Sigillaria*. This opinion, which was then contradicted, is now fully confirmed by a new and more careful examination, made by competent judges, who admit that the remains in question can represent only land-plants. We could, therefore, chronicle the presence of land covered with vegetation as far down as the Middle Silurian, if we had positive evidence concerning the origin of these remains in the locality indicated by their labels. It is, indeed, supposable that those fragments may have been found somewhere else, and have been casually mixed with specimens of the Cincinnati group, though the place of origin is positively known and vouched for by the owner of the specimens. The presence of land-plants in as low a member of the Silurian receives, however, a degree of probability from the recent discovery of remains of two species of this kind in the Lower Helderberg of Michigan. Here no doubt is left either in regard to the character of the plants, which are clearly exposed, or to the locality and its reference to the formation.* One of the species is a small *Psylophiton*; the other belongs to the genus *Annularia*, but is evidently

* This discovery is due to Dr. Roeminger, State geologist of Michigan.

new, and of peculiar characters. Both were growing together, apparently in the place where they have been found, as they are inhabited by a small fluvial or land shell, a serpulid, very much like the *Spirorbis* so commonly observed upon coal-plants of the Carboniferous. This shell is still smaller, and without the transverse striæ observable upon the species of the Coal-Measures.

The conclusion in regard to the presence of land-vegetation in the Silurian had been already recorded by Professor Dawson, but less positively ascertained, however.* He remarks that in the marine limestone of Cape Gaspé, holding shells and corals of Lower Helderberg age, they have fragmental stems and distinct rhizomes of *Psilophitum*, adding that these fragments must have been drifted from the land. In the present case, or with the vegetable remains of Michigan, the fragments are so delicate, their minute divisions so well preserved, that evidently their habitat was in close proximity to the place where they have been found, or rather that they lived in shallow basins of water bordering the shores, this being especially indicated, as remarked above, by numerous small fluvial mollusks, either placed upon the plants, or scattered around upon the stone.

Remains of this kind, evidence of open land in the Upper Silurian age, may be hereafter more frequently recorded and found also still lower in this formation when more care is given by geologists to the collection and examination of fossil plants. Though it may be of the future, these fragments of old lycopodiaceous species in the Silurian appear there as the ancestors of a long and multiple series of analogous forms, all remarkably well characterized, and which, from the Lower Devonian, increase in a remarkable proportion to the base of the Carboniferous, where their remains enter for a large proportion into the composition of the coal.

The list of the Lower Devonian plants is not as yet very long. But it is a matter of course, for the strata of this formation, at least in the United States, are mostly marine, and the fossil vegetable remains in connection with them represent marine plants which have been till now scarcely studied in this country. That they are very abundant, is proven by the fact that they have become by their presence noticeable characters of whole geological epochs to which they have given their name, as for example, *Fucoides Cauda-Galli*, for the Cauda-galli grit, the lower member of the Corniferous period.

Marine plants, though admirably beautiful they may be, some of them at least in their living state, have nothing attractive as fossils. Their fronds and branches are generally flattened by compression, and in that way, too often disfigured and generally mixed into an amorphous mass, where the eyes rarely discern any trace of organization or of configuration acceptable as reliable characters. The paleontologist, therefore, needs for the study of these plants the greatest care and a large number of specimens, which are rarely obtainable; for the plants and their ramifications either cover wide surfaces of hard rock, or penetrate it in various directions. I believe, however, that with time and perseverant researches, paleontologists will be able to determine a number of those obscure remains, and point out by their presence the distribution of some separate groups of the Devonian. But this subject is out of the present discussion.

There is in Canada a great sandstone formation known as the Gaspé, over seven thousand feet thick, which has few animal remains in its

* Fossil Plants of the Devonian and Silurian Formation of Canada, pamphlet (1871), p. 78.

compounds, and whose geological relation has never been satisfactorily determined either by stratigraphy or by animal paleontology. Professor Billing refers its lower part to the Oriskany sandstone of New York, without positive evidence, however; its middle part is doubtfully considered by Professor James Hall as representing the Hamilton group. Taking into consideration the data supplied by fossil plants whose remains have been found from the base to the top of this formation, Professor Dawson finds that they represent a succession, by multiplication of specific or generic forms, of the whole devonian flora, as far as it is known, till now, and that therefore this enormous accumulation of sandstone has been in constant process of formation during a whole epoch, exposing in its successive strata the gradual development of its vegetable types. Its divisions are not as yet positively defined by the celebrated professor of Montreal. But surely a more detailed study of the distribution of the species of fossil plants of the Gaspé will enable the paleontologist to fix, by the grouping of related forms of plants, the different stages of the devonian land formation, and thus afford points of comparison for future researches.

This we can do distinctly for the Carboniferous age, taking as its beginning or its base the Old Red Sandstone, represented in this country by the Catskill period. In the Upper Chemung, we have here, as in Canada and in England, some few remains first representatives of a peculiar group of ferns, whose characters have no relation to those of any species of our time. Its species have been described by the authors under various generic names. They are referred to *Cyclopteris* or *Adiantites* by some; to *Noeggerathia* or *Sphenopteris* by others; to *Archeopteris* or *Paleopteris* in more recent works. This multiplication of generic names does not refer to uncertainty of characters. Every paleontologist knows these plants; but their undefined analogy has forced different points of view in regard to their relation, and therefore caused this confused terminology. These ferns, from their rare presence in the Devonian, become so predominant in the red shale of the Catskill period of this country, and of the Old Red Sandstone of Europe, that they are considered as characterizing the formation by their remains. This fact is acknowledged even by geologists who do not take any account of vegetable paleontology. The more common species of this group of ferns—*Paleopteris hybernica*, *P. Roemeri*, *P. Boscii*, described first from the Red Sandstone of England, are represented in the red shale, Nos. ix and x of the Pennsylvania geological reports, (the Catskill,) below Pottsville, Mauch Chunk, and other places. *Paleopteris Halliana* and *P. Jacksoni* are American species of the same tpye. In Europe two species, *P. Reussii* & *P. unequilateralis*, ascend to the Sub-Carboniferous limestone, and here also, as will be remarked below, we have two species known already in the next higher stage of the Carboniferous. Therefore the predominance in the Catskill beds of a group of plants which is still represented by a number of species at a higher stage of the Carboniferous, marks its place with the last geological division rather than with the Devonian. These *Paleopteris* species, like those of *Megalopteris* mentioned in the following division, have often been considered as Devonian types; this, apparently, because the Old Red Sandstone has been often and is still sometimes admitted as Devonian. All the European species described are referred to the Old Red or to the Culm, or Sub-Carboniferous; those of Canada to the upper beds of Gaspé, a formation which, as remarked already, is not yet limited in its divisions, and may represent the Catskill by its upper members.

To this lower member of the Carboniferous are referable a number of

species of plants described by Prof. B. F. Meek, in proceedings of the Washington Philosophical Society (1872). The specimens, which represent three very fine species of *Paleopteris*, a *Lepidodendron*, a *Stigmaria*, and a *Carpolithes*, were obtained from Lewis's tunnel, Alleghany County, Virginia, in the lower part of the Sub-Carboniferous measures, near its junction with the Upper Devonian.

Until recently there was, between these species of plants of the Catskill and those of the Carboniferous type, a break of relation which could not be accounted for, except by the supposition of a change of formation, as it has been generally done for interruptions of this kind. Therefore, the reference of the Catskill beds to the Devonian was judicious so far; but, two or three years ago, Prof. E. B. Andrew, while connected with the geological survey of Ohio, discovered, in Perry County, in the southern part of this State, a bed of black shale, with abundant, well-preserved remains of ferns of peculiar and remarkable type. These shale, from the remarks of Professor Andrew, are at a distance above the Chester limestone, or on the upper part of the so-called Sub-Carboniferous measures of the West. Somewhat later, Mr. I. H. Southwell, of Port Byron, Illinois, sent from that locality, as discovered, also, in a bed of soft black shale, underlying the true Carboniferous measures, a number of specimens representing some of the most predominant forms observed in the shale of Perry County. This peculiar group of plants has still two species of *Paleopteris*, one of them closely allied to *P. Jacksoni*, the other, like *P. obtusa*, figured in Dana's Manual of Geology, with some of the pinnules deeply emarginate at the top, or bilobed. The majority of its species, however, are referred to *Megalopteris*, a new genus established by Dawson, and represented by ferns with immense fronds, large decurring leaflets, often divided in the middle, in two lobes, by the forking of the middle nerve. One species, of about the same character, is described by Professor Andrew* under the generic name of *Orthogoniopteris*. The specimens from Port Byron, Ill., represent, also, more generally, species of *Megalopteris*, one of them especially remarkable by the agglomeration or tufting of the terminal leaflets, which divide, above the base, in two, more rarely three, equal lobes, by the forking of the middle nerve, as remarked above. This mode of division of the leaflets is exceptional in ferns of this kind, and has never been observed except in one species of the lowest coal-bed of Illinois, the first above the millstone grit, and described in the 4th volume of the Geological Reports of that State as *Neuropteris fasciculata*.†

Professor Schimper, in his Vegetable Paleontology, mentions this species as a very singular one; and the discovery, in a lower member of the Carboniferous, of species to which this peculiar conformation is traceable, affords a point of comparison which cannot be overlooked in searching either for geological relation or for an affinity of vegetable types. Allied to the plants of the Catskill group by its *Paleopteris*, to the so-called Upper Devonian of Canada by the *Megalopteris*, the flora of Port Byron passes to that of the subconglomerate Carboniferous of Arkansas by a small *Arterophyllites*, *A. gracilis*, which is present, also, in the shales of Perry County, and described, too, in the Pre-Carboniferous flora of Canada as *A. parvula*; by *Lepidodendron modulatum* and *L. carinatum*, two species found also in Arkansas in subconglomerate coal-beds; by *Cardiocarpon Southwellii*, similar to *C. ingens*, of Arkansas; and it has, also, one species, *Sagenaria depressa*, Göpp. of the Culm or Sub-Carboniferous of Europe, and another intimately allied to

* Journal Science and Arts, December, 1875, pp. 462–466.
† P. 381, Pl. V, Figs. 1–4.

Sphenopteris crassa, described by the same author from the same formation, the *Posidonien schieffer*. The examination of a large collection of specimens from the coal-measures of Alabama affords the means of pursuing the comparison of these floras somewhat further, for, till now, the subconglomerate coal flora was merely known by the species described from Arkansas.* That of Alabama is composed of a large number of species as yet unobserved in this country; some of them, however, described by European authors, by Brougniart, Lindley, and Hutton, especially, from the lowest coal-beds of England and of Germany, inferior in station to the millstone grit.

There is, forexample, *Sphenopteris Hoeninghausii*, predominant by an immense number of specimens; three species of *Eremopteris* a coarse-veined *Neuropteris*, recalling the type of *Paleopteris* of the Old Red; many *Lepidodendron*, some identical with species of the measures above the conglomerate; some of a peculiar type, one especially, with branches covered both by leaves and scales, and *Ulodendron minus*, of the Lower Carboniferous of England. Hence we have in the subconglomerate coal of Arkansas and of Alabama another intermediate flora uniting types of the coal above the millstone grit with those of the Perry shales, as these serve as point of transition between the Catskill flora and that of the subconglomerate coal. It is thus to this point an uninterrupted series of vegetable forms.†

The characters of the floras of both stages of the Carboniferous overlying the conglomerate are well known. The lower, in connection with beds of coal of remarkable thickness, especially in the anthracite fields of Pennsylvania, has a profusion of Lycopodiaceous. There abound species of *Lepidodendron*, *Ulodendron*, *Knorria*, genera represented mostly by very large trees; some ribbed *Sigillariæ;* large-leafed species of *Alethopteris*, of a type probably derived of the *Megalopteris* of old, like *A. Serlii*, *A. Sullivantii*, *A. pennsylvanica*, *A. lonchitico*, with its numerous varieties, *A. nervosa*, which, like the former, appears already in numerous specimens in the flora of the Alabama coal; *Sphenopteris*, species also related by their character to those of Arkansas, like *S. Gravenhorstii*, *S. decipiens;* numerous species of *Hymenophyllites*, and hard fruits, *Carpolithes*, *Cardiocarpi*, and *Trigonocarpi*. All this gives to the supra-conglomerate coal a character which is especially predominant in the lowest beds. In passing up to the Pittsburgh division, or to the upper coal-measures, the constituents of the flora are gradually modified by the decreasing number of the great lycopodiaceous species, which are rarely found above the Mahoning sandstone of Pennsylvania, and by a proportionate increase of the *Sigillariæ* species, especially of the ecostate section. We have in these upper coal-measures, besides these *Sigillariæ*, a preponderance of ferns, arborescent species of *Pecopteris*, whose large fronds and pinnæ are spread upon the shale like small trees; *Pecopteris arborescens*, *P. unita*; some bushy *Neuropterideæ*; *Neuropteris Loschii*, especially the most common of all; a profusion of *Calamites* and *Cordaites*, and still one species of *Alethopteris*, *A. aquilina*, a diminutive form. Whenever remains of fossil plants are found in connection with a coal, paleontology easily recognizes their relation to the upper or to the lower division of the supra-conglomerate Carboniferous measures. From this it follows that from the base of the Catskill group to that of

* Geological Report of Arkansas, vol. ii, pp. 295–319.

† Prof. E. T. Cox, State geologist of Illinois, has quite recently sent me for determination a box of specimens from the whetstone grit, 25 feet lower than the base of the conglomerate. They represent species either identical with or intimately allied to those of the flora of the subconglomerate coal of Alabama.

the Permian, vegetable paleontology is able to discern and expose the characters of five divisions of the Carboniferous, each determined by peculiar species of plants, and each also related by analogous or even identical species to both the preceding and the following stages of the formation.

The records of the paleontology of the Coal-Measures are not less positively referable and less interesting to geology when they bear upon questions of a wider and more general application. To my knowledge no fossil plants from the Coal-Measures of North America were described before 1818; in that year Rev. Steinhauer published in the Transactions of the American Philosophical Society* his *Fossil reliquia*, where he describes and figures, under the generic name of *Phitolithus*, a few species of *Calamites*, *Lepidodendron*, *Ulodendron*, *Artisia*, *Stigmaria*, and *Sigillaria*. He mentions, however, in the introduction, that most of the specimens of fossil plants from the Carboniferous represent *Filices* (ferns). After him Granger, in 1820, merely mentions a few specimens of coal plants from Zanesville, and refers them to Steinhauer, species.† From that time to 1828, Granger, Cist, and Professor Silliman sent some specimens of fossil plants from the Coal-Measures of Pennsylvania and Ohio, to Brongniart, who was then preparing the materials for his great coal flora. They represented, as seen from this work, ten species, three of which only were then peculiar to this continent. In 1837, Dr. Hildreth, of Marietta, so well known by his love and zeal for the study of natural history, and its original researches in some of its branches, described in the journal of his geological explorations‡ a number of species whose figures are mostly unrecognizable, and whose references are equally uncertain. The remarks of the author, however, denote long and serious researches into the distribution of the coal-beds and the fossil plants recognized in their connection. For ten years after this nothing is said upon our Carboniferous flora until 1847, when Teschermacher prepared, on the fossil vegetation of North America, a very interesting and valuable, though too short memoir, published in the Boston Journal of Natural History.§ At that time the great paleontological works of Brongniart, Sternberg, Göppert, and Unger were already published, and therefore the author was able to more clearly analyze and describe the specimens which, then, very rare, as he says, were obtained from New Scotia, Rhode Island, and Mansfield, Mass. He is the first to remark upon the affinity of the Carboniferous flora of America to that of Europe, thus opening the way for a greatly-needed comparison between the coal floras of both continents, to which some questions of high interest to geology were then and are still related. Teschermacher mentions in his pamphlet twenty-three species, some of them described and obscurely figured also, all more or less positively referred to species known from European authors except one. This, he says, has no relation to any known by him. It is left without description and without name. The figure represents a fragmentary specimen of the most beautiful fern of the Coal-Measures, *Odontopteres Agassizii*, which has never been found but in Rhode Island, and of which splendid specimens are preserved in the Agassiz museum of Cambridge.

In 1850, Prof. H. D. Rogers, then director of the geological survey of Pennsylvania, requested the assistance of a paleontologist for the collection and the study of the fossil plants of the anthracite basin.

* Vol. 1, new series, p. 265.
† Silliman's American Jour. Sci., vol. iii.
‡ Ibid., January, 1836, and January, 1837, vols. xxix and xxxi.
§ Vol. v, part 3, June, 1847.

The work was systematically begun and pursued, first, by the collection and the examination of specimens of fossil plants in the different coal-strata of the anthracite, where, in some cases, coal-beds, exposed in a vertical position and therefore disconnected, were identified by their vegetable remains only. The researches were then extended for comparison in different parts of the so-called Appalachian or bituminous-coal fields of Pennsylvania, in order to ascertain if both basins, that of the anthracite and that of the bituminous coal, were positively of a same formation, and if the distribution of the fossil plants could indicate not only identity of period, but conformity in the deposits of the coal-beds. These questions have been examined and answered in the introduction to the fossil flora of the coal-measures in the final Report of the Geological State Survey of Pennsylvania, and the data which were exposed by these researches have been accepted as reliable and recognized ever since. This is followed in the same introduction by the comparison of the Carboniferous flora of Europe with that of North America, as far as this flora was then known, by more than one hundred species described and figured in the Pennsylvania geological report, and by as many more published in a catalogue of the fossil plants of the Coal-Measures, by the Pottsville Scientific Association in 1858, and reprinted in Professor Rogers's report. The intimate relation of the coal floras of both continents is there discussed and forcibly established by the exposition of identity of types, even specific identity for the greatest number of coal-plants.

Later, vegetable paleontology was called to supply some evidence in regard to the kind and degree of relation existing between the distribution of the measures of the so-called Appalachian coal-basin with those of the Indiana and Illinois coal-fields, to which belongs the western coal-basin of Kentucky. Researches of the same kind were pursued by the exploration of coal-beds and the determination of the specimens of fossil plants found in connection with them. The results of this study have been published long time ago in the geological reports of Kentucky, under the direction of Dr. Dale Owen, and in those of Illinois, under that of Prof. A. H. Worthen. They have exposed, not merely a general relation of the coal-plants of the western basins to those of the east, but in most cases an identity of species, varied only by the presence of a number of rare, peculiar forms, remarked once only at a sole locality, or seen again here and there, even at far distant points. This fact is in accordance to the laws of geographical distribution, and repeated at the different geological epochs as well as at this present time. These researches have proved also the intimate relation of the coal-strata in regard to their vertical distribution in both the eastern and western coal-fields, and therefore the synchronism of some of the more important coal-beds over the whole extent of the North American Carboniferous formations. Even then, from the harmony of distribution of the coal-strata on both the eastern sides of the Indiana and Kentucky basin and the western side of the Ohio Coal-Measures, as also from the identity of the characters of their constituent plants, it had been inferred that the upheaval of the Silurian ridge which separates them has succeeded the formation of the coal, and that therefore these now separated coal-fields have been originally united. This opinion has been contested on considerations derived from stratigraphical evidence. I think, however, that new discoveries, like that of strata of exactly the same composition, with plants of identical species, as the Sub-Carboniferous fossil-bearing beds of Perry County, Ohio, and of Port Byron, Illinois, will corroborate the conclusions dictated by vegetable paleontology. Anyhow,

these researches have demonstrated the possible identification of the coal-strata, a fact whose application, however, can become valuable to coal-mining when we have more positive knowledge on the geographical and stratigraphical distribution of the plants of the American Coal-Measures.

In the Permian, as far at least as this formation is known by the exposure of its rocks in Iowa, Nebraska, and Kansas, near the junction of the Platte with the Missouri River, the records of vegetable paleontology are blank indeed; for the sufficient reason that this formation is represented there only by magnesian limestone or marine rocks whose only fossil remains are invertebrate animals, the so-called Permo-Carboniferous species, most of them indifferently referable to Carboniferous or to Permian. But sandstone rocks have been observed in the Rocky Mountains, which, without any animal remains, have been, from the nature of their composition and from their superposition to old Paleozoic strata, considered as referable either to the Carboniferous or to the Permian. A few fragments of Calamites only, found in connection with this formation and sent for determination, were sufficient to establish its relation to the Permian, for the Calamites represented by these specimens, *C. gigas*, is a leading plant of the Lower Permian. This case was recently repeated from a locality far distant from the former, and the same reference equally established from a few specimens only. It cannot be said in this case, as for the Carboniferous, *that the general characters of the plants are well known, and that therefore vegetable remains of this formation may be used sometimes for determination, when topography and animal paleontology cannot be taken as guides;* for, to my knowledge, the above-mentioned specimens are the first vegetable remains discovered as yet from American Permian rocks.

For the Trias, the evidence supplied by vegetable paleontology is presented in opposition to that derived from animal remains, by one of the highest geological authorities of this country. This formation, exposed in North Carolina, and in Virginia near Richmond, also, has important deposits of coal, whose age has been for a long time in discussion among geologists, and has been definitively fixed by the remains of fossil plants found in connection with them. In the last work published by Emmons, American Geology, Part VI, the lower part of the section of page 17, headed Permian, is described as the Chatam series, and its fossils, a few fucoidal remains of uncertain affinity and a large number of animal remains, crustacean, mollusks, fishes, saurians, are not considered as sufficient to authorize a decision upon the age of the formation, which is therefore left as uncert in. The upper part of the measure, however, has in its divisions layers of shales, with plants, and though remains of animals are not found in connection with this series, it is positively determined as Triassic by the author, from vegetable paleontological evidence only. The characters of the plants, as indicated especially by the *Cycadeæ*, relate this flora to the Jurassic of Europe; hence its appellation of Triasso-Jurassic, given to the formation. I say the Jurassic of Europe, for indeed this formation is as yet so indefinite in this country that it has no records of any kind which may be used as points of comparison. Its flora is totally unknown; and even if we had a few vegetable remains obtained from the strata considered as Jurassic in the Black Hills, the Uinta Mountains and the Sierra Nevada, it is very questionable if they could be used for identification of the formation. The Jurassic, even for Europe, is the dark age of vegetable paleontology. Except the oolitic coal deposits of England, its strata of enormous thickness

in some regions are mostly marine, and have as yet afforded too scanty materials to define somewhat clearly the characters of its flora in the numerous subdivisions of the formation.

The Cretaceous flora of North America, as far as it is known from its representatives in Kansas, Nebraska, Dakota, and Minnesota, has been reviewed in this report and speaks for itself. Its characters, as they are known now, will be more expressively compared to those of the Lignitic flora, and the differences more distinctly seen when the Tertiary species are published with figures. From the multiplicity of its types, some of them transient or indefinite, it is now easily understood that the attempt of a comparison of the few first leaves discovered in Nebraska could but mislead the most competent and careful paleontologist in looking for typical relation in order to determine their age. The records of this Cretaceous flora could not be read, indeed, before they had been written, or when they were exposed by a few scattered words only. Now the North American Cretaceous plants represent a definite group, which, though susceptible of wide extension by new discoveries, has its essential characters already defined, and is thus available as a point of comparison for paleontological documents, either from this country or from Europe. It is in this point of view especially that the importance of the publication of the fossil plants of this country has to be judged. That the geological age of the Dakota group flora, as long as its characters were unknown, should have been subjective to the evidence afforded by its overlying marine strata, which were clearly determined by invertebrate animal remains, is a matter of course. But now this flora affords a collateral evidence which by its vegetable types may be used for geological determinations just as legitimately as the fauna. From a subordinate it becomes an assistant.

I consider that this discussion upon the authority of vegetable paleontology in regard to the determination of the age of the disputed strata, Cretaceous Lignitic or Lignitic Tertiary, has been of great value to American geological science. It has induced wide and more careful researches, and brought forth a large number of important discoveries which, without it, would have probably been indefinitely postponed. No department of geology should be disregarded or considered as of an inferior concern. All have an equal right as members of a same body. And was it only for the reason that vegetable paleontology has been generally, and is still now, considered by many as of little value as an assistant to geological pursuits, I am the more disposed to persist in putting it forward as an authority superior to that of animal paleontology for the determination of the age of the strata of land formations.

The above remarks all tend to the same purpose, and serve as an introduction to a more detailed examination of the age of the Lignitic as exposed by the fossil flora.

To appropriately enter into the subject, we should have a clear understanding of the now adopted names and limits of the numerous subdivisions or groups of the Tertiary, as marked by European authors. Though it may be that some of these groups are not positively defined, either in their geological relation or in their paleontological characters, they are serviceable for comparison.

Table of subdivisions of the Tertiary of Europe, according to the floras.

Pliocene. Lower limits not positively fixed; largely developed in Italy.

Miocene. { Oeningen.*
Mayenciau or Helvetian.†
Aquitanian.‡

Armissan, Bonnieux, and Manosque, France, intermediate between the Lower Miocene and the Oligocene.

Oligocene. Tongrian. §

Eocene. { Gypses of Aix, Alum Bay, Mount Bolca, London Clay. Sheppey, Grès of the Sarthe.

Paleocene. { Upper Landenian: Sézanne same as the Belgian Paniselian.
Lower Landenian: Sand of Bracheux, Lignitic soissonnais, (Suessonian.)
Hersian: Gelinden.
Limestone of Mons, unconformable to the Cretaceous of Maestrich, which it overlies.

Some authors consider as Cretaceous the sands of Bracheux and Gelinden, as indicated by the characters of the flora of Gelinden.

These subdivisions of the Tertiary of Europe seem to expose a prodigious thickness of the formation, and to indicate a great disproportion of vertical extent in comparison to the American measures of the same age. There may be indeed a marked difference but as vet very little is known of the Tertiary of this continent, and certainly this little takes already, by its wide area and the thickness of some of its divisions, an important place in the North American geology.

Last year Prof. F. V. Hayden discovered, near Point of Rocks, some beds of shale with rich deposits of vegetable remains, and obtained a large number of specimens. This locality is between Black Butte Station, nine miles northwest of it, and Salt Wells, another station of the Union Pacific Railroad, about the same distance farther west. From Prof. B. F. Meek's report and from my own ‖ it may be seen that from Black Butte to Point of Rocks, in following the railroad, the northeastern dip of the measures brings successively in view a series of heavy sandstones, interstratified with beds of clay and lignite, whose whole thickness, according to Messrs. Meek and Bannister, is estimated at about 4,000 feet. The series of these rocks is beautifully exposed by a diagram in the report. My own estimation gives only half this thickness. But as I did not take any measurements, the purpose of my explorations

*Represented at Locle, Montaron, Albis, Steckborn, Elgg (Switzerland); Schossnitz (Silesia); Gunsburg (Bavaria); Parschlug and Gleichenberg (Syria); Tokay (Hungary); Singaglia, Stradella, Guarene, Sarzanello, Val d Arno (Italy).

† Represented at Delmont, Deveiller, Aarwang, tunnel of Lausanne, Calvaire, Riant Mount, St. Gall, Solitude, Mönglen, Ruppen, Alstätten, Oberaegeri. Buron (as Mayencian); at Petitmont, Estave, Croisettes, Montenailles, Moudon, Payerne (as Helvetian), (Switzerland): Bovey-Tracy (England); Monte Bamboli, Superga (Italy); Menat, Gersovia (France); Le Rhön, Wetteren (Lower Lignitic), Basin of Mayence, Kempter, Gunzburg (Germany); Bilin (Bohemia); Radoboy (Croatia); Tohnsdorf, Köflach, Eibiswald (Styria); Basin of Vienna (Austria).

‡ Represented at Ralling, Schwartzachtobel, Wäggis, Vevay, Monod, Rivaz, Dezaley, Paudex, Rochette, Conversion, Brulées, Rufiberg, Rossberg, Höhe-Rhone (Switzerland); Spechbach (Alsace); Lower Succinifer Tertiary of the Baltic, Spitzberg, Iceland, including, perhaps, the whole miocene series, Greenland, Mackenzie, Alaska; Cardibone, Selzedo, Novale, Zorencedo Vegrone (Italy); Kumi, Iliodroma (Greece); Menat (France); Rot, near Bonne, on the Rhine.

§ Armissan ? Peyrac, Saint Jean of Garguier, Basin of Marseilles, St. Raccharie (Var.), Apt, Gypses of Gargas, Vaucluse, Castellane (France); Sechbach and Lobsart (Alsace); Mount Promine (Dalmatia); Sagos (Krain); Haering (Tirol); Sotzka (Styria); Peissenburg and Miesbach (Bavaria); Alsattal and Kushlin (Bohemia); Sieblos (Rhön Mountains); Beernstädt and Wüssenfield (Thuringia). ———. These data on the distribution of the Tertiary in Europe are mostly derived from Schimper's Vegetable Paleontology.

‖ Dr. F. V. Hayden's Sixth Annual Report for 1872. Professor Meek's sections and diagram of the measures are given at pp. 530, 539, 534.

in that part of the country being especially the research and study of vegetable remains, I readily admit the conclusions of these distinguished geologists who had time to attend to details of stratigraphy. As Point of Rocks Station, where the specimens of Dr. Hayden were found, is at a distance of a few miles from the cut-end of the ridge east of Salt Wells, the thickness of the measures is there somewhat less, say about three thousand feet. Though it may be, such a heavy series of strata is passed from Black Butte to Point of Rocks that if any part of the so-called Bitter Creek series is Cretaceous, we may expect to find in the fossil plants of this last locality a number of species of Cretaceous types, or at least a distinct modification in the characters of the plants. The thirty species represented by the specimens of Point of Rocks are described hereafter, but the deductions derivable from the determination of these plants in regard to evidence of geological age, will be more clearly understood by a comparative table exposing affinity or identity of characters with species of other localities. The points of comparison are indicated with the flora of the European and of the Arctic Miocene, of the Canadian Tertiary, of the European Eocene, of Golden, Black Butte, and of the Cretaceous in general.

Table exposing the relation of the fossil-plants of Point of Rocks.

Species of fossil-plants from Point of Rocks.	Canadian Tertiary.	European Miocene.	Arctic Miocene.	European Eocene.	Golden.	Black Butte.	Cretaceous.
1. Fucus lignitum		An.*	An.				
2. Salvinia attenuata		An.					
3. Selaginella falcata					An.		
4. Selaginella laciniata					An.		
5. Sequoia brevifolia		Id.	Id.				
6. Sequoia longifolia						Id.	An.
7. Sequoia biformis							An.
8. Widdringtonia complanata		An.					
9. Pistia corrugata	Id.?						An.
10. Lemna scutata	Id.!						
11. Ottelia Americana							
12. Sabal grayana				An.	Id.	Id.	Vancouver
13. Dryophyllum subfalcatum				An.			
14. Dryophyllum crenatum				An.			
15. Populus melanaria		Id.					
16. Populus melanaroides				An.			
17. Ficus asarifolia		Id.					
18. Ficus dalmatica		Id.					
19. Ficus planicostata				An.		Id.	
20. Ficus tiliæfolia		Id.			Id.	Id.	
21. Ficus irregularis						Id.	
22. Trapa microphylla		An.					
23. Laurus præstans		An.					
24. Viburnum rotundifolium						An.	
25. Viburnum Whymperi			Id.			Id.	
26. Viburnum marginatum				An.		Id.	
27. Diospyros brachysepala		Id.			Id.	Id.	
28. Greviopsis Cleburni				An			
29. Rhus membranacea		An.					
30. Juglans rhamnoides						Id.	

*An. for analagous; Id. for identical.

Of the thirty species enumerated in this table, one is identical with a Canadian species recognized as Tertiary, as seen below, from quotations of Prof. G. M. Dawson's Geological Report. Six are identical with and six also analogous to those of the Lower European Miocene, two are identical with, and one allied to, Arctic Miocene species. Six have a close relation to those of the Lower European Eocene, or rather of the

Tertiary division, separated at its base under the name of Paleocene. Three are identified and two analogous, in the flora of Golden. Nine identical and one analogous, in that of Black Butte; and four have analogy with Cretaceous forms.

The relation of Point of Rocks with the Canadian Tertiary is especially marked by *Lemna scutata*, a floating plant, described by Prof. J. W. Dawson, in the report of the geology and resources of the region in the vicinity of the forty-ninth parallel. The geologist of the commission, Prof. George Mercer Dawson, obtained the specimens from a bed of clay near the very base of the Lignitic formation, where, according to the information kindly furnished to me, the vegetable remains representing this species were very abundant, but difficult to get from the crumbling shale. Though their reference to any living species is not distinctly marked, the peculiar character of the plants does not permit any doubt about its identity with that of Point of Rocks, which is also represented by numerous specimens. Half the specimens from this place bear remains of this species and of another, *Pistia corrugata*, which may be a mere form of the same. In regard to the identity of the Lignitic measures of Canada with those of the United States, the evidence is equally conclusive. The report quoted above proves it, by good sections and diagrams, which indicate the same distribution of Lignitic beds, clay, and sandstone strata, as in the great Lignitic of the Rocky Mountains, of which that of Canada is a mere continuation. It enumerates, also, besides those which are descirbed, a number of plants from the Lower Tertiary, of a higher stage, mostly of Miocene types.

In remarking upon the fossil plants which he had to determine, the celebrated professor of Montreal, J. W. Dawson, says, "That the plants of the first group are for the most part identical with those found by American geologists, in the Fort Union series, and which have been determined by Professor Newberry and by M. Lesquereux. They are also similar to plants collected by Dr. Richardson, in the Lignitic series of the Mackenzie River, as described by Heer, and represented by specimens in the collection of the geological survey, &c. They also approach very closely the so-called Miocene floras of Alaska and Greenland, as described by Heer, and in their facies, and in several of their species, they coincide with the Miocene floras of Europe." He then adds, "If we were to regard the affinities of the plants merely, and to compare them with the Miocene of other countries, and also to consider the fact that several of the species are identical with those still living, and that the whole facies of the flora coincides with that of modern temperate America, little hesitation would be felt in assigning the formation in which they occur to the Miocene period. On the other hand, when we consider the fact that the lower beds of this formation hold the remains of reptiles of Mesozoic types; that the beds pass downward into rocks holding Baculites and Inocerami; and that a flora essentially similar is found associated with Cretaceous animal-remains, both in Dakota* and Vancouver's Island, we should be inclined to assign them at least to the base of the Eocene.

From this it seems that Professor Dawson does not separate the two essential groups of the Tertiary: the upper one with its Miocene types, a flora indicating a temperate climate like that of the middle zone of the United States; the lower one with its numerous species of Palms, of Ficus, &c., evidently representing a subtropical vegetation. In this last flora, the one which is now under examination in this paper, there is no species identical or analogous to any of those of the Dakota group.

* The assertion is right for Vancouver's Island but not for the Dakota group.

The extraordinary separation of both floras has been sufficiently established by former comparison and descriptions of species. In the upper stage some rare types of the Cretaceous re-appear. But apparently the specimens obtained by the survey mostly represented the upper stage of the Canadian Lignitic. For Professor Dawson describes and enumerates, from Porcupine Creek, seventeen species, all of Miocene type, and most of them formerly described by Professor Heer and Professor Newberry, from the Miocene formations of Alaska, Greenland, and especially from the Union group, with which the Porcupine Creek group appears closely allied. These plants are:

Equisetum species, similar to E. arcticum Heer.
Glyptostrobus Europeus, Heer.
Sequoia Langsdorfii Brgt.
Thuia interrupta Newby.
Phragmites? species.
Scirpus species.
Populus Richardsoni Heer.
Corylus rostrata Ait.
Corylus American. Walta.
Diospyros species.
Rhamnus concinnus, Newby.
Carya antiquorum, Newby.
Juglans cinerea? or J. bilinica, Ung.
Viburnum pubescens, Pursh.

To this and by comparison are added the species catalogued by Heer, from Richardson's collection on the Mackenzie, which, says Professor Dawson, belongs to the same region. They are:

1. Glyptostrobus Europæus Heer.
2. Sequoia Langsdorfii Brgt.
3. Pinus species.
4. Smilax Franklini.
5. Populus Richardsoni.
6. Populus arctica.
7. Populus Hookeri.
8. Salix Rheana.
9. Betula species.
10. Corylus Macquarrii.
11. Quercus Olafseni.
12. Platanus aceroides.
13. Hedera McClurii.
14. Pterospermites dentatus.
15. Phyllites aroideus.
16. Antholithes amissus.
17. Carpolithes seminulum.

The species described in the same report from the lower stage of the Lignitic of Canada are fewer and apparently represented by more imperfect specimens. They are *Equisetum Parlatorii*, Heer, of the Miocene of Europe, a species to which *E. Haydenii* of Carbon is closely allied. Its habitat is marked as Great Valley.

Lemna scutata sp. nov., abundant at the Bad Lands, and also at Point of Rocks.

Scirpus species, Bad Lands.

Salix Rheana? Heer (Great Valley), species of the Miocene of Greenland.

Sapindus affinis, Newby, (Bad Lands), species of the Union group.

Rhamnus, an undescribed species (Great Valley), corresponding, by its preserved part, to *R. Eridani* Ung., which is *Ficus jynx*, a Miocene species of Europe and of the upper American Lignitic also.

Aesculus antiquus, *Trapa borealis*, and *Carpolithes*, three new species, described from obscure specimens, from the same locality as that of *Lemna*, the Bad Lands, west of Woody Mountain.

From the exposition of this flora, it is not surprising that Professor Dawson should admit, as the result of his study of the fossil plants of the Lignitic, the Tertiary age of these formations. For, indeed, in this flora there is, as remarked already, no trace of any vegetable remains which, by comparison with the species of the Dakota group or with those of the Cretaceous of Europe, could be recognized as identical or even related to any of them.

Coming back to the other plants of Point of Rocks for considering their characters for an evidence of their age, by comparison with other groups of floras than that of Canada, we find in the table three of them marked as analogous to Cretaceous types. The first, *Pistia corrugata*, may be, as remarked in the description, an undeveloped or young form of *Lemna scutata*, a question here without importance. At first I considered this species as being the first of this genus recognized in a fossil state, for none has been published as yet. But Count Saporta informs me that a species, *Pistia Mayelii*, Sap. ined., has been found in the fresh-water Upper Cretaceous of Fuveau, France. From the sketch kindly communicated by the author, his species appears very different in its characters from that of Point of Rocks. The generic affinity, however, is worth remarking, for a plant so profusely represented as is our species, which, by itself or mixed with *Lemna scutata*, covers both sides of a number of large specimens.

By the same degree of affinity, I have marked in the Cretaceous column of the table *Sequoia longifolia*, also found at Black Butte, and *Sequoia biformis*; the first on account of a distant likeness to *S. Smithiana*, and the other to *S. Reichenbachi* and *S. rigida*, three species recognized, the first in the lower, the two others in both the upper and lower stages of the Cretaceous of Greenland. The wide distribution of *Sequoia* species is generally known; it is marked here by the presence of these two species in two stages of the Cretaceous. But without taking into account the longevity of these forms, we have to consider that if we have here two conifers merely related to Cretaceous species, this cannot eliminate the testimony of *Sequoia brevifolia*, which is as profusely represented in the flora of Point of Rocks as *Pistia*, and by specimens in a perfect state of preservation. One-half of the specimens of Mr. Cleburn, besides a large number of those of Professor Hayden, show it in its two somewhat different forms. As it is distinctly and easily determined, its characters being precise, and as this conifer is a representative of the Miocene flora of Greenland and of that of the Baltic, its documentary evidence is more positive than that of the two other *Sequoia* represented as yet by small fragments, and merely allied to Cretaceous types.

I consider as referable to the Eocene by analogy of distribution *Sabal Grayana* and the two species of *Dryophyllum* of Point of Rocks. That Palms have originated in the Cretaceous is now an established fact. Schimper, in his Vegetable Paleontology, indicates as from Cretaceous formations two species of uncertain affinity. And nevertheless, in a more recent work, the Flora of Gelinden, by Saporta and Marion, the authors remark that one species of Palms only was known by its fronds

from the Cretaceous. The recent discovery by Schweinfurth of a fruit, *Palmacites rimosus*, Heer,* in the Upper Cretaceous white chalk of the oasis of Chargeh, west of Thebes (about 25° latitude north), is another evidence of the presence of palms in the Upper Cretaceous. That, however, remains of this kind are extremely rare even at the end of the Cretaceous is proved by the importance attached to the discovery of a fruit of this kind in a region under the tropic. From the Paleocene, as represented in the floras of Gelinden and of Sezane, no species of Palms have been positively determined. For the fragments described in this last flora under the generic name of *Ludoviopsis* are indefinitely referred by the author either to the Pandaneæ or to the Palms. As yet, of the fifty species of known fossil Palms from their fronds, twenty belong to the Miocene, especially to its lower stage; eight are described from the Tertiary of Italy, without reference to any of its divisions, nine are Oligocene, twelve Eocene, and one Cretaceous. Of the eight species of Sabal described, one species is Miocene, two Oligocene, and five Eocene. *Sabal andegavensis* Schp., and *S. precursoria* Schp., two species of the Upper Eocene of France, are very closely related, the first to *Sabal communis* of Golden, the other to *Sabal Grayana* found in many localities of the Lower Lignitic, from Mississippi to Vancouver. In considering the Lignitic flora by the specimens of fossil plants from Black Butte, Golden, Colorado Springs, the Raton Mountains, &c., where the preponderance of remains of Sabal and Flabellaria is so marked, how could it be possible, if even we had no other characters for direction, to refer it to the Cretaceous? The above speaks plainly, and shows how I had to recognize the flora of Vancouver as Tertiary, from the numerous specimens of Sabal sent by Professor Evans from Nanaimo, even if the other plants of the locality had not represented Tertiary types. It was the same case for the flora of the Mississippi State, where the Palms are also in preponderance. At Point of Rocks, four large specimens upon sandstone represent the same species of Sabal as that of Vancouver and Mississippi, *S. Grayana*, which, in the opinion of a celebrated European paleontologist, is one of the finest and most positively characterized species of the genus.

The two species of *Dryophyllum* described from Point of Rocks are indicated in the table of distribution as analogous to the Eocene. This genus represents a separate section of the oaks, corresponding by the form of the leaves and the indentations of their borders to the Chestnut-oaks of the present North American flora. Messrs. Debey and Ettingshausen have separated it for the classification of some leaves found in the Cretaceous of Belgium. It represents, therefore, a Cretaceous type, which, however, like some others of the same formation, *Fagus*, *Platanus*, &c., does not appear to have reached its full development from or at its origin. We see it, for example, in the Dakota group flora, in the proportion of two species in about one hundred and thirty, while in the Paleocene flora of Gelinden it has four species in thirty, and the same number in forty-eight in the flora of Sezane. It then re-appears by more or less numerous representatives in analogous species of *Quercus*, and may therefore be followed nearly without interruption to the present time. From this it is clear that the reference of fossil species of this genus, when remarked in connection with remains of Tertiary plants, should more appropriately pertain to the Eocene than to the Cretaceous. Therefore if the presence of species of *Dryophyllum* in the Point of Rocks flora, and that also of *Pitsia*, *Sequoia biformis*, and *Sequoia longifolia*, im-

* Ueber fossile fruchte der Oase Chargeh, O. Heer, in Denks. der Schweiz, Naturf. Gesells., vol. xxvii, 1876.

prints to it an odd physiognomy, it is either as remnants of the past, merely recording a few features of old generations passed away, or as contemporaneous long persistent types, which do not distinctly characterize any peculiar epoch. As proof of this assertion we have the true Lower Eocene character marked in the same flora of Point of Rocks by four species, *Ficus planicostata*, *Viburnum marginatum*, *Populus melandrioides*, and *Greviopsis Cleburni*, which evidently, related to species of the Sezane flora, though in various degrees, have no affinity whatever to Cretaceous types.

The flora of Point of Rocks is related to that of Black Butte by nine identical forms or by one-third of its species. In considering the evidence of synchronism, the identity of two floras could not be more positively proved than this, and nevertheless we have here two to three thousand feet of interposed measures. It is a remarkable fact, upon which more will be remarked presently. The group of plants at Point of Rocks has, besides the Eocene representatives, six species identified with, and as many related to those of the Miocene of Europe. Therefore we see here, what has been remarked in other localities of the Lignitic, a compound or admixture of old and young tertiary types, in comparison at least with the fossil floras of Europe, and thus a general character which does not distinctly relate to any peculiar stage of European Tertiary. We have the Paleocene by relation to species of Sezane; the Upper Eocene, especially the Ligurian or Oligocene, by the Palms, and the Miocene by a number of common and generally distributed forms which, like *Sequoia langsdorfii*, *Populus mutabilis*, *Ficus tiliæfolia*, *Cinnamomum mississipiense*, *Rhamnus rectinervis*, *Juglans rugosa*, &c., are omnipresent and constant types, indicating merely the Tertiary age for the Lignitic flora. For this reason I shall continue to carefully record its points of affinity with the divers groups of the geological floras of Europe; but at the same time denying as yet sufficient evidence of identity to any of them I persist to consider it simply as the Lower Eocene flora of this continent. I said above that the identity of specific forms at Point of Rocks and Black Butte was worth recording more carefully, as a remarkable case in regard to the distribution of plants. In marine strata the long preservation of types is a matter of little concern, for the circumstance under which the marine faunas are distributed may be the same for very long periods, as, for example, the mineral elements entering into the compounds, the depth and temperament of the water, &c. But that a comparatively large number of land or fresh-water plants, subject to modifications or forced to migrations by atmospheric changes, may be preserved identical through the lapse of time indicated by the thickness of the measures heaped along Bitter Creek, has not been proved by as positive an evidence as we have it here. The distance between both localities is eleven miles only, and the superposition of the strata is all along so clear, that there is no possibility of any mistake in the calculation of the vertical space separating both points. It is scarcely possible to hazard a conjecture upon the length of time indicated by the building up of these intermediate measures. Evidently of a shore formation, the heaping of their materials may have been more rapid than for the deposits at the wide bottom of the sea. They evidence, however, in their succession, a series of sandstone beds which though of greater thickness are interstratified by beds of clay, built up of swampy deposits of long duration and especially of coal-beds, still more clearly denoting the slow progress of the work.

A geological fact like the one remarked between the relation of the floras of Point of Rocks and Black Butte and the positive evidence of the

long periods of time and formations which separate them is an instructive document, whose importance as point of comparison in the study of the geographical distribution of our present flora and of its analogy to ancient types will be easily accepted by botanists. But here it has to be considered merely in connection with the question of the age of the Lower Lignitic.

The Cretaceous Dakota group is separated from Point of Rocks by a thickness of strata about the same as that which is marked between Point of Rocks and Black Butte. Nevertheless, between the floras of the Nebraska and Kansas Cretaceous and that of Point of Rocks and Black Butte, we find scarcely any analogous type, and not a single identical form. The erosions may have indeed considerably thinned the marine strata representing the Cretaceous above the Dakota group, but that cannot lessen the strength of the deduction made from the total disconnection of two floras, one of which denotes by its essential characters a marked dissimilarity of atmospheric circumstances, a weighty evidence, if not a positive proof, of a change of epoch, if not in the sea, at least upon the land. It is useless to repeat that, as yet, no marine invertebrate remains of Cretaceous type have been discovered in the whole Lignitic measures above Point of Rocks. We may admit, however, that while the Tertiary age was, at its beginning, represented as a land formation, as seen by its flora, a Cretaceous marine fauna may have still locally persisted in deep seas. Facts of this kind are recorded in European geology. The presence of the Saurian Agathaumas in the Lignite bed of Black Butte is then certainly explainable as denoting the wandering of that animal out of its domain, and its death by penetrating into a peat-bog and being irretrievably swallowed by its soft matter. If once imbedded in soft peat, no animal, not even man, can get out of it. By this fact, and also from the reason that the coriaceous, ligneous plants of the bogs are not food for mammals, I explain the scarcity of bones of Eocene animals in the lower beds of the Lignitic. As a shore formation, a surface covered with deep bogs surrounded by sand wastes, this primitive land would not afford food to mammals or even be accessible to them. Every one who has explored a peat-bog knows how these formations are deprived of animal life. Very few bones of the Aurochs have been found in the bogs of North Germany, and the area covered by the Lignitic shows how compact and continuous, not to say universal, were those swamps of the Lower Tertiary. I believe, therefore, that if the bones of Eocene mammals are not discovered in the lowest part of the Lignitic, they will be found in the upper strata. Moreover, the agglomeration of bones in certain localities depend on peculiar circumstances, and do not immediately and forcibly relate, like plants, to the general characters of a whole period.

The question of the subdivision of the Lignitic or Tertiary measures, which I have separated in four groups, from the non-coincidence in the general character of the flora, is still disputed, and this division contradicted by the assertion that the discordance is merely apparent, and a result of the geographical distribution of species, as we may see it now in groups of plants at distant localities. The contemporaneity of the fossil floras is not merely marked by the identity of some species, but also by a kind of general character denoting the same climatic circumstances. The modification due to the geographical distribution may be easily recognized by the presence or absence of a number of species in the flora of the Bitter Creek basin, of that of Colorado, the Raton Mountains, the Lower Union group, the Mississippi, and Vancouver. There is between these localities a wide dis-

tance; and, indeed, the Vancouver flora may show, in its details, marked points of dissimilarity to that of the Mississippi. But, one of the prominent characters of the Lower Lignitic is the predominance of Palms, and we find it manifest in all the localities named above. Indeed, I have found remains of Palm, especially of Sabal, whenever I have seen Lower Lignite beds; and, as it has been remarked formerly, *Sabal Grayana* has been observed on specimens from Vancouver, Point of Rocks, Golden, the Mississippi, &c. With this there are, in all these floras, a predominance of subtropical forms, and the absence of northern types, rendering more evident their correlation in time. Sufficient details have been given on the species of the group, and on their distribution, in Dr. Hayden's former report (1873), p. 378 to 390.

The group of plants of the Evanston division has, as yet, no remains of palm-leaves, but fruits doubtfully referable to the Palm family; with this it has some of its species of leaves represented at Golden, others at Carbon. The general character of its flora does not indicate as high an average degree of temperature as that of the Lower Lignitic. The group has been separated, as an intermediate one whose relation is not positively fixed now. According to Professor Cope's description, bones of Eocene vertebrate animals have been found in connection with it. Its true horizon may be rendered more definite by further discoveries. But in the group of Carbon the general character of the flora is evident, and its relation to the Miocene of Europe and of Greenland is exposed, not only by this general kind of related facies, but also by a number of species, like *Platanus aceroides and Guillelmæ*,* *Acer*, *Populus arctica*, *Taxodium dubium*, *Alnus Kefersteinii Betula*, *Quercus*, *Corylus*, indicating, together with the total absence of Palms, a marked difference in the climatic circumstances governing the flora and that of the Lower Lignitic group. This difference, also, is not remarked at Carbon only. It is reproduced in the same degree, by general affinity and identity of species, in the flora of Coral-Hollow, San Joachin County, and of Contra Costa, south of Mount Diablo, California; of Bridge Creek, John Day Valley, and of Blue Mountain, Oregon; of Bellingham Bay, of Alaska, as established by Heer's flora of that country, and therefore followed northward from Carbon to Greenland. Some of its types are so definite that a single specimen of a species of *Acer* or *Platanus* would suffice to positively identify this group as Miocene, just as a few specimens of *Quercus furcinervis* proved the Eocene age of the Cascade Mountains of Oregon, whose formations were at first supposed to be Post-Tertiary or of recent origin.

A few words more will be sufficient to answer the other objections recorded at the beginning of this paper against the value of vegetable paleontology in its application to geology for the determination of the age of the formations. We know now well enough that remains of fossil plants are abundantly found in the land deposits of this continent. The result obtained from the onset of American researches in vegetable paleontology let us surmise what an immense amount of documentary data the after-coming geologist shall be able to gather in the same field. The authority of animal-remains shall continue undoubted as far as it refers to marine formations. But when land formations are to be considered, the authority should, when evident, be accepted as decisive.

* The fragment of leaf found in connection with the bones of the Saurian at Black Butte, and considered, from the character of nervation of the middle of the leaf, the only part preserved, as doubtfully referable to *P. Guillelmæ ?* was identified from better specimens, showing the outlines of whole leaves, as a new species of *Viburnum*, described in this paper as *Viburnum platanoides*.

There may be some exceptional cases where both kind of evidence may be in opposition, however, and afford reasons for dispute of authority. For example, no Cretaceous invertebrate marine remains have been found in the strata of the Lignitic above Point of Rocks, nor in the Bitter Creek series above this point, nor in the whole extent of the Colorado Basin; hence the plants, being characteristic and Tertiary, the whole formation should be admitted as Tertiary, of course. But Vancouver shows, as far as its flora is known, identity of characters of its fossil plants with those of the Lower Lignitic, as known, from the above-named stations; its relation is therefore defined as land formation, and this should be to my persuasion considered as evidence of synchronism and therefore of its Tertiary age, though the beds bearing Tertiary plants may be locally and casually overlaid by marine strata with Cretaceous animal-remains. This case has some analogy with that of the presence of the bones of a Cretaceous Saurian at Black Butte.

Conformability or uncomformability of stratification proves very little in regard to the changes which are considered as indicating a new epoch or period. Of course the disturbances of wide-expanded surfaces of the earth modify in various degrees the atmospheric circumstances, and, in a less degree, however, those which govern the distribution of animals under water. Therefore the changes in the characters of the floras or the faunas may be more or less evident in correlation with these disturbances. But these are more generally so gradual that they cannot be remarked by traces of unconformability, and the consequences in modifications of marine or land beings can be appreciated only at very long distances of time. Gradual changes of this kind seem to have progressed during the whole period of the Cretaceous formations of the West, from the base of the Dakota group to that of the Tertiary Lignitic, and later still; for in the whole vertical space occupied by the deposits no unconformability of strata is remarked. But the concurrence of gradual atmospheric modifications with those of the earth surface is distinctly recognizable in the general character of the flora of the lower Lignitic compared to that of the Dakota group, this being of a temperate climate, while that of the Lignitic proves a subtropical one. Of course the life under deep seas cannot be modified in the same degree and in the same period of time. It is but very slowly influenced by land atmospheric changes, and from this there is in some instances between the inhabitants of the land and those of the sea, a forcible geological discordance, like that exposed at Black Butte by the Saurian and the plant's remains wherein it was imbedded.

Perhaps the more weighty objection against the deductions taken from the characters of the Lower Lignitic flora is that of the unreliability of comparison between the vegetable types of both continents in their relation to supposed synchronous epochs. From this objection it is said that we should not attempt, in regard to the distribution of the North American fossil plant, to consider anything known of the geological relation of those of Europe. This objection appears at first trifling, and it seems that it could be answered by the mere assertion that as American paleontologists have constantly taken their points of comparison from Europe, in considering the relation of the animal remains to the age of the strata where they were discovered, vegetable paleontology should be allowed to use the same privilege; for no section of natural science can be defined and progress *a priori* or without means of comparison, and where to find any if the European scientific domain should be closed. But in this objection there is something more than the mere privilege of comparison. It seems positive that from its

first appearance the American land flora has a proper American character, recognizable not merely in differences, but in priority of types. I have already alluded to this phenomenon, which, though seemingly observable in many instances, is, however, not positively ascertained as an actuality, and not referable to a principle of a general application. We have, as far as our knowledge goes, a precedence of vegetable Devonian types which are already seen in the Silurian; the Carboniferous, also, are recognized by remains of Lepidodendron as low as the Marcellus epoch. The Sub-Carboniferous flora of this continent is mostly Devonian for Europe, and the Lower Carboniferous has a number of specific forms, considered by European authors as Permian. Farther up, the Trias is Jurassic by its *Cycadeæ*, and the Cretaceous of the Dakota group is typically allied to the Miocene species, and still more to the present flora of this country. If it is so, the objection expressed above is a mighty one, for then our Lignitic flora might be of an older period and representative of an American Cretaceous formation, though having already the characters of European Eocene floras? We have, in this peculiar case, a point of reliable comparison which answers the objection. The flora of Point of Rocks, considered as Tertiary, is probably at the lowest stage of the formation. Its characters have been exposed in a table of comparison. Now, the floras of Gelinden, in Belgium, and of Sézanne, in France, are connected with strata acknowledged by stratigraphy and animal paleontology as of the oldest European Tertiary. And here as at Gelinden, for example, the Cretaceous type, represented by *Dryophyllum*, is far more evident than at Point of Rocks, and in the flora of Sézanne it is about in the same proportion as in that of Point of Rocks and Black Butte. In this case, therefore, no trace of precedence of vegetable types is remarked on this side of the Atlantic, and the floras of both continents, offering evident synchronism by stratification, and both animal and vegetable paleontology, may be considered as giving reliable evidence by the comparison of their characters.

It is claimed that the opinion on the Tertiary age of the Lignitic contradicts evidence admitted by the highest scientific authority. Though no personal opinion may be recognized as authoritative in science, we have, on the question discussed here, a concurrence of views expressed by Dr. Newberry for the Lignitic flora of the Union group of the Upper Missouri River, and by Prof. J. W. Dawson for that of Canada. These are certainly the highest authorities in this country. From Europe, the opinion of Count Saporta, who is deeply interested in the progress of the botanical paleontology of this country, is not less explicit. After the examination of some of the plates prepared for the flora of the Lignitic, he writes: "That *Sphenopteris Eocenica* is closely allied to *Asplenium Wegmanni*, Brgt., of Sézanne; that species analogous to what I have described as *Abietites dubius* and *Abietites setigera* have been found in the Upper Cretaceous of St. Paulet, France; that our Palms, especially *Palmacites Goldianus*, denote Eocene; that the magnificent species *Sabal Grayana* is allied to, and perhaps an ancestor of, *Sabal major*, which in Europe appears at the beginning of the Miocene; and that *Flabellaria communis* is extremely similar to *Sabal andegaviensis*, which is found in the Eocene Superior of the south of France, but which has not been figured till now." From all this and other points of affinity which the celebrated paleontologist of France makes in regard to the species of the lower group of the Lignitic flora, he concludes as follows:*—"In re-

* In letter, October 19, 1875.

suming, and notwithstanding that *Abietites*, which I consider as a Cretaceous type, your first group seems indeed to be legitimately Eocene, by its Ferns, its Palms, its coriaceous and prototypical Poplars, its *Cinnamomum*, and its *Viburnum*, as related to the Sézanne flora, and by one of its Palms to the Upper Eocene of Angers. If one would suppose this flora more recent than the Eocene, he would have to admit such a dissemblance between Europe and America that every comparison by the floras between the geological stages of both continents should appear an impossibility." The assimilation of American species with a number of Miocene species published in Europe is considered by Saporta as doubtful and not quite conclusive; and he remarks, also, that, though his opinion on the age of the Lower Lignitic group is given according to present impression, the great geographical distance renders the affinities between compared localities very difficult to fix with precision, even in supposing them contemporaneous.

These quotations must be excused by reason of the importance given now to the question of the age of the Lignitic, which, controverted in various ways, demands light, and has to be considered in every possible point of view. The problem is not yet solved. Requested, as I am, to contribute a share in the discussion, by closely adhering to paleontological evidence, and exposing it as far as it is given by fossil plants, I had to enter into details in order to show its weight. And no better opportunity could be afforded for this purpose than a review of the group of plants obtained from Point of Rocks by Dr. Hayden.

From the following descriptions it will be remarked that some of the specimens have been found and communicated to the survey by Mr. William Cleburn, of Omaha, a zealous explorer and student of the vegetable paleontology of the Western Territories.

Description of species of fossil plants from Point of Rocks.

K 1. FUCUS LIGNITUM, *sp. nov.*

Frond flattened, irregularly dichotomous; branches diverging obliquely; branchlets short, terminal, linear-divaricate, tufted, forking at the point.

The fragment figured is the only one of this kind in the specimens. It represents a species allied to *Sphærococcus crispiformis*, Sternb., as described in Heer's Flor. Tert. Helv. (p. 23, Pl. IV, fig. 1), and still more, perhaps, to the living *Fucus canaliculatus*, Agh., very common along the coasts of the Baltic Sea, and also discoverd in numerous specimens in the Tertiary of Spitzbergen. The base of the lowest branches is four millimeters broad, but the size of the branchlets diminishes nearly one-half at each dichotomous division. The terminal branchlets are only half a millimeter broad, fasciculate-dichotomous, short, split, or furcate at the point, and divaricate. The substance appears thin, membranaceous, and yellowish.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

K 2. SALVINIA ATTENUATA, *sp. nov.*

Leaves small, one centimeter or less in diameter, opposite, joined at the narrowed, slightly-pediceled base, round or broadly oval, indistinctly reticulate by vertical and parallel rows of quadrate, large cells, marked in the middle by black spots, formed by very small, close cells, or pores, without any trace of a middle nerve.

This fine species is related by its reticulation and its size to *Salvinia Mildeana*, Heer (Balt. Flor., p. 17, Pl. III, figs. 1 and 2), differing from

it by broader, less distinct, square areolæ, the absence of a dividing middle nerve, and the narrowing of the base to a very short pedicel. By these two last characters, this species is unlike any of this genus. It is, however, probable that the two leaves representing it were not, when embedded into the clay, in their full state of maturity, one of them being smaller than the other, and its areolation far less distinct. In the young leaves of the living *Salvinia natans*, the leaves, before attaining their full development, have the middle nerve scarcely discernible.

HABITAT.—Point of Rocks, *William Cleburn*.

K3. SELAGINELLA ? FALCATA, *sp. nov.*

Frond small, dichotomous; pinnæ narrow-linear, one to four centimeters long, six to seven millimeters broad; pinnules close, two-ranked, in right angle to the rachis, generally covering each other at the borders, falcate upwards, lanceolate-acuminate, suddenly narrowed to the point of attachment, without distinct middle nerve.

I have figured four different parts of this plant, which is abundantly scattered among the floating rootlets and upon the specimens of the *Lemna ? Scutata.* It may represent some kind of floating fern, perhaps, rather than a species of *Selaginella.* It is, however, closely allied to *Selaginella Berthoudi*, Lsqx., described in Dr. Hayden's Annual Report for 1873 (p. 395), differing, however, by the two-ranked position of the leaves and their distinctly falcate form.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, *W. Cleburn*.

One of Mr. Cleburn's specimens represents a fragment of a stem ten centimeters long, one centimeter broad, round, but flattened by compression, covered with densely imbricate leaves of the same form and size as those of the branches. This stem proves the relation of the described fragments to the lycopodiaceous family.

K4. SELAGINELLA LACINIATA, *sp. nov. ?*

Branches dichotomously divided; divisions two to three centimeters long; leaflets ? opposite, distichous, divided from the base in three to five filiform laciniæ, some of them forking at the middle, all curving upward, or falcate.

By its mode of vegetation, the form and divisions of the pinnæ or branchlets, these small plants are exactly similar to those described from Dr. Hayden's specimens under the name of *Selaginella falcata*. The difference is in the remarkable laceration or thread-like divisions of the leaflets. The laciniæ distinct and *in relievo* upon the stone are like the veinlets of fern-leaves, when, by maceration and decomposition, their epidermis has been destroyed, or like skeletons of leaves. In this case, however, as these thread-like branches are more or less numerous, either simple or forking from the middle, and thus differing in number and mode of divisions for each leaflet, this appearance cannot result from decomposition in water. It is probable that these remains represent a kind of lycopodiaceous plant, living sometimes partly immersed, and that, as it happens in numerous species of water-plants of this epoch, the immersed leaves become decomposed, and grow into laciniate divisions, while the emerged ones are entire or undivided. This difference in the leaves is particularly marked in *Nasturtium lacustre*, Gray, known to every botanist. I do not know, however, any Lycopodium species showing this kind of variations in leaves. Even *L. inundatum* has the leaves of the immersed part entire or without divis-

ions. It is therefore uncertain if the specific separation of these fragments is authorizable.

HABITAT.—Point of Rocks, *William Cleburn.*

5. SEQUOIA BREVIFOLIA, Heer.

Branches flexuous; branchlets opposite or alternate, open and diverging near the base, then curving upward and erect from the middle to the top. Leaves of two kinds, either small, short, scaliform at the base of the branchlets and covering the whole of them when young, or oblong, enlarged in the middle, obtuse or abruptly narrowed to a point, and gradually and slightly so toward the decurring base, distichous, oblique, decreasing in length toward the base and the top of the branchlets. We have a large branch* and numerous more fragmentary specimens of this fine species described by Heer in Flor. Arct. (p. 93, Pl. II, fig. 23), from Greenland specimens, in Flor. Spitz. (p. 37, Pl. IV, figs. 2–3), from Spitzbergen specimens, and formerly in Fl. Baltica (p. 21, Pl. III, fig. 10). It is well characterized by the form of its generally short open distichous leaves, either abruptly pointed, or obtuse, deeply nerved, and slightly decreasing in width from above the middle to the base. We have, however, a number of specimens with somewhat narrower, nearly linear, longer leaves, which show a notable deviation of the normal form. The cone of this species is not known as yet. One of the specimens bearing scattered branchlets and leaves of this *Sequoia* has a cone, which appears to be a flattened cross-section, or perhaps the flattened base of the cone turned upward, the pedicel marking the central point around which the scales, oblong, cuneate, narrow, emarginate at the top, are imbricated to the borders. These scales rather resemble those of a *Glyptostrobus* than those of a *Sequoia.*

HABITAT.—Point of Rocks, *Dr. F. V. Hayden, Wm. Cleburn,* whose collection has about one-half of the specimens representing this species in its normal form, and its variety.

6. SEQUOIA LONGIFOLIA, Lsqx., MSS.

Branches thick; leaves closely appressed, erect, long linear lanceolate-pointed or accuminate, enlarged above the slightly contracted and decurring base; scars deep, lingulate-pointed, marked by a deep groove in the middle.

This species was already described from Black Butte specimens; these have, some of them at least, longer leaves than those of Black Butte. In these, the leaves average two and a half to three centimeters long and three millimeters wide; in those of Point of Rocks, the leaves, of the same width, are generally five centimeters long, even more. In both forms, they are marked by a broad indistinct middle nerve, and the surface, seen with the glass, appears very thinly striated in the length. This character, as well as the thick consistence of the leaves, seems to prove the identity of the species, though the leaves of the specimens of Point of Rocks are not only longer but proportionally narrower and scarcely contracted to the point of attachment to the branches. In both, these leaves are generally crowded and covering the stem.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

7. SEQUOIA BIFORMIS, *sp. nov.*

Stems thick, pinnately branching; branchlets short, obliquely diverging; leaves either linear or somewhat broader in the middle, grad-

* A beautiful specimen, the property of Mr. E. H. Clarke, agent of the Union Pacific Railroad, who kindly lent it for illustration of the species.

ually narrowed to a point, slightly contracted to the decurrent base, slightly incurved or falcate, sometimes erect and appressed to the stem; scar-leaves triangular or lingulate-pointed.

This species apparently bears two kinds of leaves, even upon the same specimens; either long, two centimeters, and very narrow-linear, less than one millimeter wide, or shorter and broader, decreasing gradually from the base to the point, linear-lanceolate, nearly one and one-half millimeters wide and only eight to ten millimeters long; the middle nerve is deeply marked upon both kinds of leaves. I should have considered the numerous specimens bearing branches of this *Sequoia* as representing two species, the one with narrow longer leaves, the other with shorter broader leaves. But even the difference in the length and proportionate width of the leaves is distinctly perceivable upon one of the specimens, and the difference also in the length of the leaves, all narrow and of the same width, is evident upon another. There are, moreover, a large number of specimens, all fragmentary indeed; and the difference in regard to the size of the leaves is apparent upon most of them. In the average, the leaves are much narrower than those of *Sequoia Reichenbachi*, Heer, to which this species is related by the falcate form of some of the leaves.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

18. WIDDRINGTONIA COMPLANATA, *sp. nov.*

Stem thick, disticho-pinnate; branchlets short, thick, alternate, oblique; leaves small, in spiral order, closely imbricate and appressed, oblong-lingulate pointed upon the primary branches, ovate-pointed or rhomboidal and shorter upon the obtuse branchlets.

This species, represented by many specimens, is evidently related to *Widdringtonia antiqua* (Sap. Et., 2, 1, p. 69, Pl. I, fig. 4), for the form of the leaves, which are, however, more closely appressed in the American species, and more distinctly placed in spiral order around the branchlets. These leaves do not appear of a thick substance, the coat of coaly matter over them being extremely thin.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, *William Cleburn.*

19. PISTIA CORRUGATA, *sp. nov.*

Leaves thick, at least toward the base, varying in diameter from two to three and one-half centimeters, broadly obovate, generally bordered from above the base by a wavy margin two to five millimeters broad; gradually narrowed into a short pedicel about three millimeters thick, terminating into a bundle of radicles; veins emerging from the pedicel in two or three thick bundles, dividing and diverging from the base of the leaves, and forming in ascending, by a kind of abnormal anastomosis, irregularly polygonal meshes.

These leaves, resembling in form a small bladder, contracted on one side, seem somewhat inflated, or at least thickened, from the base to above the middle, or composed of two distinct areas, the lower one circular and separated by a narrow groove, or deep line, from the wrinkled border which surrounds it, narrowing, however, gradually toward the pedicel. The areolation of this border seems disconnected and distinct, representing large quadrangular areolæ, whose subdivisions curve along in festoons. Sometimes, however, the central part is not inflated, or thicker, and in this case, as in specimens representing young leaves, no traces of borders are perceivable. This groove, therefore, and the separation of the leaf in two distinct parts, may be caused by a kind of fold

around a tergescence of the lower part, formed by an abnormal growth of radicles. The upper surface of the leaves is somewhat rough; the lower surface, inside of the fringe, is dotted with minute holes, or like spongious. The leaves are generally mixed, or superposed to thin foliform long radicles, all of the same size, coming in bundles from linear rootlets, two to five millimeters thick. They form a thick coating surrounding the leaves, or whereupon the leaves are floating, without evident connection or point of attachment to them.

At first I supposed these leaves as representing the same species as the following, but their relation to species of *Pistia*, whose leaves are flat and not like vesicles, seems to indicate, though the likeness in some of the characters may be, that these organs represent two kinds of water-plants. Comparing this one to leaves of *Pistia spathulata*, Mich., from specimens of Louisiana, the affinity is remarked not only in the obovate shape of the leaves, but in the kind of nervation, by inflated primary veins diverging from the base of the pedicel, where they pass into bundles of radicular filaments of the same characters as those of the fossil plant. Most of the leaves of the living species, the old ones especially, bear from the middle to the base an inflated spongious coating similar to that which is observed on the under surface of the fossil leaves. The more marked difference is in the central part of the fossil species, which appears surrounded by a distinctly-marked deep line, while in the leaves of *P. spathulata* the thick zone, though definite, terminates in passing upward along the primary veins; but this difference, like that of the areolation along the borders, is specific only and the generic identity appears clearly defined.

HABITAT.—Point of Rocks, very abundant, and covering by itself only large surface of shale, *Dr. F. V. Hayden*, *Wm. Cleburn.*

10. LEMNA SCUTATA, Daws.

Fronds round, entire, slightly undulate on the edges, sometimes an inch in diameter, single or grouped; roots numerous, filiform, proceeding from a round spot near the notch of the frond.

To this species, as described and figured by Professor Dawson (Report on the Geology of the Forty-ninth Parallel, Appendix A, p. 329, Tab. XVI, figs. 5 and 6), I refer a number of round bodies, leaves or fronds, mixed with the species described above. Comparing them with the author's figures, there is no difference whatever, except that if some of them do not show any trace of veins, others, exactly of the same shape, are veined from the base, where the radicular filaments are attached to them and the veins distributed as in the former species. Some specimens also, one of which has been figured, show the basilar part inflated, or the pedicel wherefrom the veins are diverging, just in the center of the circular organism, as if it had been a bladdery or vesicular plant, flattened by compression. I still believe that both the leaves described above and these represent the same kind of vegetable, these being the young and yet undeveloped organs. All the different appearances of these plants, represented by numerous specimens, have been figured, and the comparison of their various forms will, I think, satisfy paleontologists in regard to their relation to a species of *Pistia.*

HABITAT.—Point of Rocks, mixed with the former, *Dr. F. V. Hayden*, *Wm. Cleburn.*

11. OTTELIA AMERICANA, *sp. nov.*

Spathe ovate narrowed to a round pedicel, surrounded by an undulated and wrinkled fringe, emarginate at the top.

The central part of this organism, representing the spathe of a water-plant, is oval, somewhat inflated, narrowed to a round pedicel, and surrounded by a margin or fringe half a centimeter broad, cut or emarginate at the top. The middle part is slightly inflated and striate in the length. The border fringe is opaque, and does not show any appearance of nervation. Comparing it to a figure of *Ottelia alismoides*, Pers., from Ceylon, kindly communicated by Saporta, the fossil plant seems in perfect concordance of characters with the living.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, represented by one specimen only, in a good state of preservation.

12. SABAL GRAYANA, Lesqx.

Trans. Am. Philsoc., vol. xiii., p. 412, T. xiv., figs. 4–6.

Frond apparently large, represented by fragments only; rachis flat, elongated linear-acuminate, six to eight inches long, enlarged at its base and rounded on both sides; rays numerous, gradually enlarging upward, half to two and one-half centimeters broad, marked with distant and distinct slender veins. The characters of this species have been described in detail as quoted above. The species is always easily identified by its slender though distinct and equally distant veins.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

13. DRYOPHYLLUM CRENATUM, *sp. nov.*

Leaves oblong, lanceolate, abruptly oblique to the petiole or subtruncate; borders deeply, regularly crenate; substance of the leaves somewhat thick, subcoriaceous; surface rough; nervation pinnate, middle nerve flat and broad, lateral veins diverging sixty to sixty-five degrees, flat, distinct, slightly curving in ascending to the borders subcamptodrome, the veins forking up under the sinuses of the teeth, and a branch passing up along the borders from the point where the veins enter the teeth; nervilles thick, in right angle to the veins, forming, by subdivision and anastomosis, a square or indistinctly polygonal areolation.

Of all the species described of this genus, none is comparable to this one, which is especially distinct by its broadly obtusely dentate borders. It is represented by two fragmentary specimens.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

14. DRYOPHYLLUM SUBFALCATUM *sp. nov.*

Leaf subcoriaceous, linear-lanceolate, acuminate or sharply pointed; borders regularly serrate with short blunt teeth turned upward; lateral veins parallel, diverging thirty to forty degrees, straight to the point of the teeth; fibrillæ close, thin but distinct, simple or ramified in the middle, the upper ones joining nearly in right angle, a branch veinlet which pass from near the point of the lateral veins under the sinuses, and follows along and close to the borders.

There is only a fragmentary specimen of this species, the upper half of a leaf. By its form and nervation, it seems at first referable to the genus *Castanea*, and, truly, it would be easy to find leaves of the present *C. vesca* apparently perfectly similar to this fossil one. There is, however, a difference in the areolation, or in the arrangement of the tertiary veins. In these primary types of *Quercus* and *Castanea* described under the name of *Dryophyllum*, the upper branch of the secondary veins passes from near the point of the vein under the sinuses and closely follows the borders, which thus sometimes appear narrowly marginate, and is joined nearly at right angle by the upper fibrillæ. This charac-

ter, though still indistinctly traced in the leaves of *Castanea*, and of some species of chestnut-oaks, is far less regular, the upper branches which follow the borders being of various sizes, not so exactly parallel to the borders, and not in close proximity to them. This new species is intimately related to *Dryophyllum Dewalquei* Sap. & Mer. (*Flor de Gelinden*), especially to the fragment figured in Pl. III, Fig. 2. It differs only by the shorter, less acute teeth of the borders, the slightly falcate form of the leaf, and the close thin fibrillæ.

HABITAT.—Point of Rocks, *Wm. Cleburn.*

15. POPULUS MELANARIA, Heer.

Leaves with a long, slender petiole; deltoid, subtruncate at base; borders acutely serrate; primary basilar lateral nerves emerging from above the border base of the leaf, with a pair of thin marginal veinlets underneath.

Considering what can be seen of this leaf from the fragment which represents merely its lower half, with the long, slender petiole, the distinct nervation, and a few of the border-teeth, it exhibits characters in accordance with those described above, and translated from Schimper's Vegetable Paleontology, and especially with the figure given of this species in Flor. Tert. Helv. (Pl. LIV, fig. 7). Professor Herr remarks, that it essentially differs from *Populus latior*, var. *subtruncata*, by the position of the lateral primary nerves at a distance from the border-base of the leaves. In the leaf figured as indicated above, this distance is still greater than in that in the Flor. Helv. Heer remarks also that he has seen a large number of specimens of the same species, but that in all except one, which he has figured, the upper part of the leaves was destroyed, as it is in ours. He mentions as distinctive characters, the acutely serrate borders of the leaves, and the middle nerve thicker than the lateral ones, the same as seen upon our specimen. I have, therefore, no doubt about the relation of this leaf to the European species.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

16. POPULUS MELANARIOIDES, *sp. nov.*

Leaf subcoriaceous, nearly round, subtruncate at base, long-petioled; borders undulate; nervation ternate from above the base of the leaf, secondary veins two pairs, at a great distance from the primary ones, these much branched outside; the others simple, all the divisions passing to near the borders, where they become effaced in the areolation; nervilles thick, flexuous, in right angle to the veins, forming by ramification at right angle square polygonal meshes.

By the subcoriaceous substance, the long slender petiole of the leaves, this species is referable to the section of the *Trepidæ* (Trembling Poplars). As in *Populus tremulæfolia*, Sap. (Et., 3, 2, p. 26, Pl. III, fig. 4), to which this species is allied, the veins and their branches pass through the areas to very near the borders, which they seem to reach. The American form differs merely by less-distinctly undulate borders, the distance of the primary lateral nerves above the base, and by the great distance of the secondary veins. These two last characters are, however, of no moment for the specification of poplar-leaves, as can be remarked in the examination of a few leaves of the too common *Populus alba*. In fossil species, *Populus Massiliensis*, Sap. (Et., 3, 2, p. 30, Pl. II, fig. 6), is represented by three leaves, each of a different character of nervation. The relation of this species with that of the Tertiary

(Miocene?) of Provence, described by Saporta, may be therefore more intimate than it appears from the comparison of a single leaf. Our species is also comparable to *Populus heliadum*, Ung., by its form, and to *P. melanaria*, Heer, by its nervation.

HABITAT.—Point of Rocks, *Wm. Cleburn*.

17. FICUS ASARIFOLIA, Ett.

Leaves petioled, broadly reniform, subcordate or subpeltate, very obtuse, small, with borders crenulate; primary nerves palmately five to seven; middle nerve straight; upper lateral ones strong, curving inward, branching and anastomosing with the upper secondary veins; veinlets transversal, their ramification forming a protuberant, or embossed, very distinct, polygonal areolation.

Though this species has been already briefly described from specimens found at Golden, in Dr. F. V. Hayden's report for 1872 (p. 378), it had as yet not been figured, the fragments of leaves being generally too incomplete. It is, however, easily recognized by its peculiar nervation, forming small, elevated, polygonal areolæ, an areolation like an embossed checker-board, resembling that of *Asarum Europeum*. The fragments of Golden seem to be part of much larger leaves than those of Ettinghausen, who described the species in Bilin Flora (p. 80, Pl. XXV, figs. 2–3). These *per contra*, from specimens of Point of Rocks, are perfectly well and entirely preserved leaves, rather smaller, except one, than the leaves of Bilin. They are also slightly more expanded on the sides, or reniform, and the crenulations less distinct, but these border-divisions are, for their size, related to the areolation, which is wider in proportion of the size of the leaves. Our leaves, also, are evidently peltate, at least in two of the figured specimens. One only has the position of the thick petiole marked similarly to that of the European leaves; but even the representation of the species by the author seems to indicate peltate leaves, whose borders are erased at the base or at the point of attachment of the petiole. The differences are too unimportant to be considered as specific characters. These leaves merely represent a local variety, or a *var. minor*. This species appears to be rare in the Tertiary of Europe, as it has till now been seen only in the plastic clay-beds of Bilin.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, *Wm. Cleburn*.

18. FICUS DALMATICA, Ett.

Leaves narrowly ovate, obtusely pointed, narrowed to a short petiole; middle nerve thick toward the base, thinning upward; basilar lateral nerves, from above the border-base of the leaves, thin, ascending at an acute angle of divergence of thirty degrees to the middle of the leaf; secondary veins more open, equidistant; nervation camptodrome, joined by transverse nervilles.

In considering the figure by the author in Flora Promina (Pl. VII, fig. 11), there is no difference whatever between the European form and ours; but the description says that the secondary veins are branching at the point, and there is no trace of divisions of veins observable upon our specimens. As, however, the figured single leaf shows merely transverse nervilles and not real branches, and as these nervilles are also visible on the American form, it is apparently identical. One of the leaves represented in our plate seems rounded at the base. This is caused by its reversement into the stone, the upper part of the leaf being flat and the lower curved down in entering the stone where the extreme base and petiole are imbedded.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*.

19. FICUS PLANICOSTATA, Lsqr.

Dr. F. V. Hayden's Report on the Geol. Survey of the Terr. 1872, p. 393.

A small leaf in a perfect state of preservation represents this species very common at Black Butte. It is easily recognized by the broadly ovate, thickish, entire leaf, slightly pointed or obtuse, rounded or subcordate at base, short-petioled, three-nerved from the top of the petiole, &c.

HABITAT.—Point of Rocks, *Wm. Cleburn.*

20. FICUS TILIÆFOLIA, Heer.

Like the former, it has been described previously in Dr. F. V. Hayden's Report for 1871, p. 287, from specimens of Washakie station; mentioned in supplement to this report, p. 12, from Evanston; p. 6, from Placière anthracite; in same report, for 1872, p. 375, from above the Gehrungs coal, near Colorado City; and p. 393, from Black Butte station. We have also specimens from Golden and other localities; for here, as in the Miocene of Europe, this fine species, so easily identified, is distributed through the whole thickness of the Lignitic, excepting, however, the upper stage, that of the Green River group, where it has not been found as yet. I have figured it from specimens of Point of Rocks, not merely because it is there clearly represented, but to show more evidently the relation of this locality with the Tertiary Lignitic.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

21. FICUS IRREGULARIS, Lsqx.

This species was published under the name of *Ulmus? irregularis*, in Dr. F. V. Hayden's Report for 1872 (p. 378), the generic reference being then uncertain. Numerous specimens obtained later from Black Butte, where the species is common, shows a thick inflated leaf-stalk, a character which indicates the relation to *Ficus*. The specimen of Point of Rocks is like the counterpart of one already engraved from Black Butte specimens; the identity of characters is unmistakable, and therefore it was figured also as another record of identity of the flora of both localities.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

22. TRAPA? MICROPHYLLA, *sp. nov.*

Leaves small, round, or broadly oval, obtuse, rounded to a short petiole, with borders denticulate from below the middle, three-nerved from the top of the petiole, or irregularly pinnately nerved; lateral veins at an acute angle of divergence, fifteen to twenty degrees, flexuous, with dichotomous branches, all craspedodrome; areolation by subdivision at right angle, polygonal, distinct.

These leaves vary in size from a little more than one centimeter long and nearly as broad to about two and a half centimeters long and nearly two centimeters broad. They are generally oval-obtuse, somewhat enlarged toward the round point; the borders are minutely dentate except at and near the base, rounded to a comparatively long and slender petiole, the only one of the leaves where it is preserved being eighteen millimeters long, and its petiole nine millimeters. The areolation is peculiar, in square or polygonal areolæ, formed by close, thick nervilles, anastomosing with veinlets parallel to the veins and their divisions, the areolation being clearly defined, and the parietes as thick as the veins. The same kind of areolation is remarked upon the lower surface of the leaves

of *Trapa natans*, which, though comparable to the fossil ones by the areolation, has its borders deeply toothed and a much thicker consistence. In this species, the leaves appear membranaceous and as pellucid, so distinctly marked in black appear the nervation and the areolation upon the yellowish substance of the leaves. These leaves are mixed with the filaments or rootlets described with *Lemna? bullata*, and represent evidently a kind of water-plant. No fossil leaves published as yet are, to my knowledge, comparable to these, except those described by Professor Newberry, in the Report of the Colorado Exploring Expedition by Lieut. S. C. Ives (p. 131, Pl. III, fig. 5), under the name of *Neuropteris angulata*. The outline or general form of the slightly dentate leaves, the pinnate nervation, and the remarkably acute angle of the secondary veins are characters common to both species; even the irregular though oo obscurely marked division of the secondary veins seems to be of the same kind. It may be remarked that Professor Dawson has observed and described a fruit of *Trapa* found in connection with his *Lemna scutata;* therefore in circumstances similar to those where these leaves, referred to *Trapa*, are found.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden*, *Wm. Cleburn.*

23. LAURUS (PERSEA) PRÆSTENS?, *sp. nov.*

Leaf coriaceous, large, broadly lanceolate or elliptical, narrowed upward to an acute point, and downward in the same degree to a thick, short petiole; middle nerve thick; secondary veins strong, parallel; nervilles distinct; areolation very small, lightly marked.

The very fine and well-preserved leaf is sixteen centimeters long from the base of the thick petiole, which is one centimeter long, five centimeters broad in the middle, where it is the widest, and has thick secondary veins regularly branching, with distinct nervilles and the areolation of a *Laurus*. The foliaceous substance of the lower part of the leaf is destroyed, but the middle thick nerve and the petiole are preserved, as well as the outline-borders. By its nervation, this species is allied to *Persea speciosa*, Heer, differing by the form of the leaf and the thick middle nerve. By these two last characters, it is comparable to *Laurus princeps*, Heer (Fl. Tert. Helv., II, p. 77, Pl. XC, figs. 17–20), differing, however, by the secondary veins somewhat thicker and slightly more distant. It is most closely related to the present *Laurus Canariensis*, Sm.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

24. VIBURNUM ROTUNDIFOLIUM, *sp. nov.*

Leaf nearly round, small, surrounded by a black border, slightly and distantly denticulate by extension of the borders at the point of contact of the secondary veins and of their branches, all craspedodrome; secondary veins open, diverging fifty to sixty degrees, equidistant, parallel, the two lower pairs ramified, the upper ones only forking near the borders; areolation distinct, from parallel distant fibrillæ, branching and anastomosing in large equilateral meshes.

The black borders of the leaves, the general characters of nervation, and the facies are the same as in the other species of *Viburnum* published from Black Butte. This leaf differs especially by its nearly round form, the base rounded to the petiole, the secondary veins more open, and especially the very small, slightly-marked teeth of the borders. But for this last character, this leaf could be referred to *Viburnum platanoides*, Lsqx., as represented by the small leaf of Pl. XXXVIII, fig. 10, of the

ined. Lignitic Flora. In this, the secondary viens are, however, more oblique and more distant. It may be a mere local variety.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

25. VIBURNUM WYMPERI, Heer.

This species has been described in Dr. F. V. Hayden's Report for 1873, p. 382, and referred, with some doubt, to the Greenland species described in Arct. Flor. (II, p. 475, Pl. XLVI, fig. 1^b). The secondary veins in our species are more distant and less regularly parallel. Though its relation to the arctic species is somewhat doubtful, it does not show any difference whatever from that of Black Butte.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

26. VIRBURNUM MARGINATUM, Lsqx.

The specimen is fragmentary, but the species, very common at Black Butte, is recognizable.

HABITAT.—Point of Rocks, *Wm. Cleburn.*

27. DIOSPYROS BRACHYSEPALA, Al. Braun.

Described already in Dr. Hayden's Report for 1872 (p. 394), from specimens of Black Butte, and in Report for 1873 (p. 401), from specimens of Sand Creek, Colorado, a locality identified with Golden by its flora. But none of the leaves found as yet are as well preserved and as well characterized as that of Point of Rocks, which is especially comparable to the leaves in Heer's Fl. Tert. Helv. (Pl. CII, fig. 2). The species is not rare in the Miocene of Europe, especially in the lower groups, and appears equally widely distributed in our Lower Tertiary.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

28. GREVIOPSIS CLEBURNI, *sp. nov.*

Leaves of medium size, subcoriaceous, ovate, rounded, and narrowed by an inward curve to the short petiole, sinuato-denticulate, three-nerved from above the base; primary veins thick; secondary veins, two or three pairs, distant from each other, and also from the primary nerves, all branching outside with subdivisions or veinlets entering the teeth; nervilles in right angle to the veins, flexuous, simple, or branching in the middle; areolation obsolete.

This fine leaf, about five centimeters long (the point is broken), four centimeters broad in its widest part, below the middle, is so remarkably similar by its form, the denticulate borders, and the nervation, to *Greviopsis orbiculata*, Sap. (Sezane Fl., p. 411, Pl. XI, figs. 11 and 12), that its generic identity is positive. It specifically differs by its larger size, the more distant veins, and the double ramification of the primary nerves. This ramification is more distinct and more generally multiple, the branches forking before reaching the borders and curving along them. The leaf has, like those of the European species, a subbasilar marginal veinlet, which follows the borders, and is united by nervilles in right angle to the primary lateral nerves above.

HABITAT.—Point of Rocks, *Wm. Cleburn.*

29. RHUS MEMBRANACEA, *sp. nov.*

Leaves small, membranaceous, thickish, oblong, obtusely-pointed, rounded or subtruncate at base, irregularly coarsely duplicato-dentate; lateral veins open, the lowest decurving to the middle nerve, craspedodrome, more or less ramified.

Of this species, there is the point of a leaf, and another one nearly entire, though somewhat lacerated, about two and a half centimeters long, including the petiole (three millimeters), and one and a half centimeters broad, oblong or lingulate, with borders cut from the base in comparatively large, pointed teeth, either simple or with small protuberances on the back of the largest ones; nervation craspedodrome, the secondary veins entering the large teeth, and more or less irregularly and obscurely dividing in very thin branches, joined in the middle, and forming a large, scarcely distinct areolation. By the form of the leaves and the border-divisions, this species is comparable and closely related to *Rhus Pyrrhæ*, Ung., as figured in Tert. Flor. Helv. of Heer (Pl. CXXVI, fig. 20), which has leaves, round truncate at the base, and short-petioled, as in one of our specimens. Like *Rhus Pyrrhæ*, it is also comparable to *Rhus aromatica* Ait., a very common species of our present flora. This has also generally doubly dentate teeth, and, in southern specimens, a thickish, membranaceous consistence.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

30. JUGLANS RHAMNOIDES, Lsqx.

A small leaf of this species, which is not yet, however, definitively limited, as seen from the description in Dr. F. V. Hayden's Report for 1871 (p. 294), and which may be identical with *Juglans Leconteana*, Lsqx., and *Cornus acuminata*, Newby. Though it may be of the value of the species, the leaf from Point of Rocks is identical in all its characters, even in its size, with some of those found in the burned beds of red shales at Black Butte.

HABITAT.—Point of Rocks, *Dr. F. V. Hayden.*

The three following species have been sent also by M. Cleburn from near the Alkali stage-station, on the Sweetwater road, about thirty miles north of Green River station of the Union Pacific Railroad. The proprietor of the specimens did not himself visit the locality, but obtained them from another party, who did not give any details on the relative position of the beds where they were discovered. They represent three species, all new.

The character of the leaves, as also the presence of remains of Palms at the same locality, seem to indicate about the same station as that of Point of Rocks or Black Butte. They are described, therefore, as of the same group.

1. ALNITES UNEQUILATERALIS, *sp. nov.*

Leaves thin, variable in size, broadly oval or ovate-pointed, rounded to a short petiole; borders crenato-serrate; nervation pinnate; lateral veins irregular in number and distance, curving in passing to the borders, at an angle of divergence of fifty to sixty degrees, and entering the teeth by their ends or by small branchlets, when they pass under the teeth and follow the borders.

These leaves vary in size from four to eight centimeters long and from three to six centimeters broad, one of the sides measuring generally one-fourth in width more than the other. The irregularity in the number of the veins is correspondingly great; one of the leaves, the smallest for example, has, on one side, five lateral veins, the lower much branched outside, and on the other, ten, all simple. The largest of the leaves of this species, which is represented by a number of specimens, is related by form and nervation to *Populus Lebrunii*, Wat., which Saporta

considers as referable to his *Alnus cardiophylla.* It is represented in the Sezane Flora (Pl. XV, fig. 8). The general facies of the American leaves is, however, different, the teeth being broader and more obtuse, the nervation more distinctly pinnate, and the disposition of the veins to enter the teeth by their extremity more marked; and compared to *Alnus cardiophylla*, it is especially different by the constant inequality of the leaves. This last character and the irregularity of nervation are not of frequent occurrence in the leaves of *Alnus*. *Alnus viridis* and *A. serrulata* are, however, sometimes irregularly veined, and the inequality of the sides is seen in a number of fossil species, *Alnus cycladum*, Ung., especially *A. sporadum*, Sap.

HABITAT.—Alkali station, *Wm. Cleburn.*

2. JUGLANS ALKALINA, *sp. nov.*

Leaves pinnately compound; leaflets lanceolate, tapering upward to a long acumen, either narrowed or rounded to a short petiole; borders crenulate; lateral veins distant, mostly alternate, parallel, separated by short intermediate tertiary veins, curving in passing toward the borders at an open angle of divergence, and ascending high along them in festoons; nervilles in right angle to the veins, branching in the middle, and forming, by subdivisions, irregularly quadrate or polygonal meshes.

This species is represented by four leaves, and its characters distinct. It is comparable to *Juglandites peramplus*, Sap., and *Juglandites cernuus*, Sap., both of the Sezane flora, partaking of some of the characters of both. It is, however, still more intimately allied to *Juglans Bilinica*, Heer (Flor. Tert. Helv., III, p. 90, Pl. CXXX, figs. 5–19), from which it merely differs by the position of the lateral veins at a more acute angle of divergence following higher up along the borders, and by the thicker and more numerous tertiary veins.

HABITAT.—Alkali station, *Wm. Cleburn.*

3. CARPITES VIBURNI, *sp. nov.*

Seeds or nutlets cordate obtuse, five to seven millimeters long, three or four millimeters broad, convex, grooved in the middle from the point to the base, surrounded by a membranaceous pellicle, the remains of an apparently fleshy outer envelope. They resemble seeds of a similar kind which I have found in great quantity at Golden, and referred to the genus *Viburnum*. Their form is like that of the seeds of *Viburnum Whymperi*, Heer (Spitz. Flor., p. 60, Pl. XIII, figs. 22 and 27).

HABITAT.—Alkali station, *Wm. Cleburn.*

NEW SPECIES OF TERTIARY FOSSIL PLANTS BRIEFLY DESCRIBED.

The following-described species have been discovered since the publication of the last annual report of Dr. F. V. Hayden's Geological Survey of the Territories. They are represented by specimens sent from different localities indicated, with each species, as well as the name of the discoverer. All these species have been figured for the second volume of the Contributions to the Fossil Flora of the Western Territories.

1. SPHERIA RHYTISMOIDES, *sp. nov.*

The spots formed by this small fungus upon the bark of some stems and the leaves of a *Myrica* are composed of circular perithecia, placed

five or six in a circle, forming thus a small crenulate ring. The perithecia become connected sometimes, apparently by decomposition; they are, however, generally separated. The size of the spots varies from one to two millimeters.

HABITAT.—Black Butte, upon *Caulinites Sparganioides.*

2. HYPNUM HAYDENII, *sp. nov.*

Stem rigid, sparingly divided in nearly opposite, short branches, inflated toward the top, or club-shaped; leaves closely imbricated all around, lanceolate-acuminate or sharply pointed, concave. Comparable especially to *Hypnum Boscii*, Schwgr., an American species of the present time.

HABITAT.—South Park, near Castello Ranch, *Dr. F. V. Hayden.*

3. LYGODIUM MARVINEI, *sp. nov.*

A single leaflet of this fine species. It is simple, ligulate, obtuse, serrulate above, hastate at base; middle vein and veinlets distinct; veins forking once or twice. Allied to the living *Lygodium venustum* which ranges from Mexico to Brazil.

HABITAT.—Top of gypsum series, Grand Eagle junction, *A. R. Marvine.*

4. LYGODIUM DENTONI, *sp. nov.*

Leaflets bi-tripartite, with short, obtuse divisions and broad sinuses, broadly triangular, rapidly narrowed to a subcordate or subtruncate base, entire, bi-trinerved from the base; primary nerves distinct, like the veins, which are forked once or twice, and become very close along the borders.

HABITAT.—Green River group, near the mouth of White into Green River, *Prof. William Denton.*

5. GONIOPTERIS PULCHELLA,? Heer.

An intermediate form, represented by mere fragments of pinnæ and separate pinnules. The shape of the pinnules united to the middle refers it to *G. pulchella*, while by the less pointed leaflets and the nervation it represents *G. Fischeri* of the same author.

HABITAT.—Golden, in sandstone, above coal.

6. ZAMIOSTROBUS ? MIRABILIS, *sp. nov.*

This species, whose reference to *Zamiæ* is not positively ascertained, is represented by a fragment, the half cross-section of a silicified cone, about fourteen centimeters in diameter. The outer surface is marked by the rhomboidal obtuse top of black seeds, or stony fruits, surrounded by a white vasculoso-cellular matter. In the cross-section of the cone, these seeds, of an enlarged rhomboidal form, three to three and a half centimeters long, six to eight millimeters broad, of the same size in their whole length, or slightly narrowed to the base, appear fixed or implanted into a zone of whitish, subpellucid mass of celluloso-vascular filaments. Under this ring of white matter, one centimeter thick, comes the central part, or axis of the cone, represented by mixed fragments of blackish opaque matter, agglutinated and amorphous. The fruits, or seeds, are represented by a black, compact, opaque silex, pierced in the length by large pores or ducts passing from the top to the base of the fruits. The intervals between them, nearly as large as the seeds, are filled by the same whitish celluloso-vascular matter which composes the white zone wherein the base of the fruits is embedded. The

figure only of the specimen can give a good idea of this fragment of cone. It is distantly comparable, for the form and the disposition of its surface-scars, to *Androstrobus*, a genus established by Schimper for some cylindrical cycadeous male cones, formed of imbricated scales bearing sessile anthers on their lower surface. For the position of the fruits, it has a distant relation to *Zamiostrobus gibbus*, Reuss., a cone which shows, in its section, oblong seeds, in right angle to the axis, with their tops appearing at the outside surface. Both these cones are figured in Schimper's Veget. Pal. (Pl. LXXII, figs. 1, 2, 14, 15). There is, however, a great difference in the very large size and in the characters of this silicified strobile with those of a *Zamia*. It apparently represents a peculiar genus of the *Cycadineæ*.

HABITAT.—Found loose around Golden, *Dr. F. V. Hayden*.

T 7. SEQUOIA AFFINIS, *sp. nov.*

Branches long, slender, pinnately branching; leaves short, oblong, imbricated and obtuse; or longer, lanceolate-acute, erect or slightly reflexed; branchlets bearing cones, open; strobiles small, round-oval, obtuse; scales large, rhomboidal, with entire borders, a central oval mamilla, and wrinkles passing from it to the borders all around; male branches erect, with more acute and open leaves, resembling sterile branches of *Glyptostrobus Europeus*, with small, round catkins, covered to the top by imbricated lanceolate leaves.

This species, of which we have numerous and admirably well-preserved specimens, is much like *Sequoia Coutsiæ*, Heer, of the Bovey-Tracy flora, differing, however, from it by the more obtuse point of the scale-like leaves, by more acute and longer leaves of the sterile branches, by more slender branchlets bearing cones at their ends, by proportionally larger, more oval cones (not globular), by the indistinctness of a middle nerve on the back of the leaves, which appear merely convex or inflated, etc. The seeds are of the same size as those of *S. Coutsiæ;* they differ also somewhat by a cordate base and a mere trace of middle nerve near the top, where it divides and passes on both sides, curving along the borders.

HABITAT.—Middle Park, *Dr. F. V. Hayden*.

K 9. SEQUOIA ACUMINATA, *sp. nov.*

The form of the leaves is about the same as in *Sequoia longifolia;* they are, however, generally shorter, narrower, less crowded upon the stems, and especially distinct by the smooth surface of the leaves. In this species, the denudated branches are striate, while, in the former, they bear the scars of the base of the leaves. This difference, however, may be merely the result of decortication in the specimens representing this last species.

HABITAT.—Black Butte.

T 10. SEQUOIA?, species.

Cones flattened, apparently long, linear-obtuse, marked at the surface by shields of scales, (apophyses,) the only organs preserved. These are separated from each other, not continuous nor imbricate, rhomboidal in outline, with acute sides, and rounded top, bearing in the middle a round mamilla, from which wrinkled lines are diverging to the borders. The specimen represents two crushed cones, of which nothing can be seen but what is described here.

HABITAT.—Middle Park, *Dr. F. V. Hayden*.

11. ARUNDO REPERTA, *sp. nov.*

Stem thick, articulated; surface striated, marked with round, obtuse knots, either placed on the articulations or here and there upon the stem, without normal distribution; ear of seeds crushed, representing lanceolate glumes, sharp-pointed and rounded at base, and ovate-lanceolate-acute seeds, truncate at the base, with the center elevated or convex, apparently covered with a coating of hairs. The glume is longer than the seeds, and nerved in the middle.

HABITAT.—Green River, west of the station, *Dr. F. V. Hayden.*

12. ARUNDO OBTUSA, *sp. nov.*

Though the specimen is not as well preserved as that of the former species, the characters of the organs which it represents are discernible, and indicate a marked specific difference. The striæ or primary veins of the small fragment of a branch are thick, more distinct, and evidently separated by four or five thinner secondary veins; the glumes and pallets are shorter, equally striate, without middle nerve, and the seed is much shorter, broader, obtuse at one end, and truncate at the other. The fragment which I consider a pallet is slightly emarginate or truncate at the point.

HABITAT.—Golden, South Table Mountain.

13. PALMACITES GOLDIANUS, *sp. nov.*

Species representing a large fragment of a flabellate leaf with five to nine rays on each side, of a flat, narrow, linear rachis. Rays averaging one and a half centimeters broad, marked by deep, narrow furrows, without costæ, joining the rachis in an acute angle of twenty degrees, united to it by their whole undiminished base, without decurring along it. Surface somewhat shining; substance thick; primary veins distinct at least in some places, where the epidermis is destroyed, two to two and a half millimeters distant, separated by ten secondary veinlets, thin, but often discernible to the naked eyes.

HABITAT.—Golden.

14. SABAL COMMUNIS, *sp. nov.*

Leaves of medium size, borne upon a nearly flat or merely convex petiole, its top passing at the upper side into a short acuminate rachis, while on the lower side it is cut horizontally or nearly truncate; rays not very numerous, the lowest in right angle to the rachis, not descending lower than its base, rapidly enlarging, carinately folded near the point of attachment to the rachis, becoming mostly flat or scarcely carinate upward; carinæ narrowly costate; primary veins broad, generally black when the epidermis is removed, one to two millimeters apart; intermediate veins thin and numerous, averaging twelve in the large intervals of two millimeters. This species is closely related to *Sabal andegaviensis*, Schp. of the Eocene of Angers, France.

HABITAT.—Golden, where it is common.

15. MYRICA LUDWIGII, Schp.

Leaves of middle size, subcoriaceous, oblong or linear-lanceolate, gradually tapering into a long entire acumen, distantly and deeply dentate along the borders; middle nerve thick; secondary veins subopposite, open, parallel, curving in passing to the borders, camptodrome, forking at the base of the teeth, the branches entering them, while the top of the veins is curved along the borders.

HABITAT.—Green River group, near mouth of White River, *Prof. W. Denton.*

T 16. MYRICA INSIGNIS, *sp. nov.*

Leaf membranaceous, large, narrowly-oval or oblong acuminate, pinnately-lobed; lobes short, entire, turned upward, triangular-acute; lateral neins open, slightly curving in passing to the point of the lobes; tertiary veins nearly as thick as the secondary ones, forking under the acute sinuses of the lobes, the branches ascending along the sides; areolation large, polygonal, formed by the anastomosis in the middle of the areas of nervilles at right angle to the veins. There are of this beautiful species two fragments of leaves, indicating the average size of ten centimeters long and four centimeters broad. The point, as in the former species, is entire, and still more rapidly and acutely acuminate; and the lobes, alternate, short, equal and similar, give to this species a beautiful appearance.

HABITAT.—Middle Park, *Dr. F. V. Hayden.*

T? 17. MYRICA ? LESSIGIANA, *sp. nov.*

This species is represented by nearly the half of the leaf, enormous, at least if it belongs to this genus. Leaf linear, oblong in outline, deeply lobed; lobes opposite, ovate-lanceolate, obtusely pointed, at an open angle of divergence, entire, joined at a short distance of the thick middle nerve in obtuse sinuses; lateral veins thick, subopposite on an open angle of divergence, ascending to the point of the lobes, ramified from the middle upward in branches curving to and along the borders; tertiary veins, variable in thickness, relative position and direction, some forking under the sinuses, and passing up on both sides of it; others traversing the large intervals between the base of the secondary veins and the borders of the lobes, and following the borders in multiple festoons; areolation of the same character as in the former species, the large areolæ, however, being subdivided in very small meshes of the same character.

This magnificent leaf seems of a pellucid texture, though thick; at least, all the details of areolation and nervation are distinctly perceivable in black upon the chestnut-color of the leaf. Though the fragment does not represent one-half of the leaf, the terminal leaflet being destroyed, and the base also, still it is twenty-three centimeters long and eighteen centimeters broad, each lobe being nine to ten centimeters long from the middle nerve to the point, and seven and a half centimeters broad between the sinuses. It is doubtful if this leaf represents, as the former, a species of the section of the *Comptonia*. It resembles *Comptonia grandifolia*, Ung., which was till now considered as the giant representative of the section, but whose leaf is scarcely half as large as this. The nervation and areolation of this leaf are of the same character as that of *Myrica*, identical, indeed, to that of *M. Matheroniane* Sap., Et. II, 2, p. 93, T. V., Fig. 7, whose lobes are also of the same form. It is much larger, however, too large it seems for a *Myrica*. By the form of the leaf it is comparable to *Aralia multifida* Sas, Et. I, 1, T. XII, f. 1 and 1[a], and also but more distantly to *Cussonia polydrys* Ung., Flora von Euboea, p. 47, T XVII, f. 1.

HABITAT.—Found in connection with a bed of lignite west of Denver, Colo., and kindly communicated by *Mr. W. H. Lessig*, who discovered it, and had the specimen framed in a bedding of plaster.

18. BETULA VOGDESII, *sp. nov.*

Leaves small, ovate, acutely-pointed, rounded, and narrowed to the petiole, minutely serrulate, penninerve, lateral veins distant, opposite at or

near the base, simple or rarely branching, passing up in an angle of divergence of thirty to thirty-five degrees, nearly straight to the borders, craspedodrome; details of areolation obsolete.

HABITAT.—Near Fort Fetterman, in connection with a profusion of remains of *Taxodium distichum*, *Lieutenant Vogdes*.

19. CASTANEA INTERMEDIA, *sp. nov.*

Leaves proportionally long and narrow, linear-lanceolate pointed, narrowed to the base; borders equally and sharply dentate; teeth acuminate, turned upward; areolation and nervation similar to that of *Castanea Vesca*. By its character it is intermediate between *Castanea Ungeri* of the Miocene and *C. vesca*.

HABITAT.—Middle Park, *Dr. F. V. Hayden*.

20. CARPINUS GRANDIS, Ung.

This species, so common in the Miocene of Europe, is represented in our flora by a number of leaves identical in all the characters.

HABITAT.—Near Florissant, South Park, *Dr. F. V. Hayden*.

21. QUERCUS HAIDINGERI, Ett.

Leaf ovate-lanceolate, narrowed to the base (point broken); borders obtusely crenato-serrate; lateral veins numerous, close, on an angle of divergence of forty to forty-five degrees, rarely branching, camptodrome and craspedodrome. The leaf appears to be tapering to a point. It is upon coarse sandstone, and the details of areolation are totally obliterated. By its form, the divisions of the borders, and the nervation, it agrees with the characters of the species, except that in this leaf the middle nerve is not thick, as described by Heer.

HABITAT.—Green River, *Dr. F. V. Hayden*.

22. PLANERA UNGERI, Ett.

Leaves short-petioled, ovate, acuminate, narrowed to the base, simply, coarsely serrate from the middle upward; secondary veins nine pairs, passing up to the point of the teeth in an acute angle of divergence. This form, though represented by one leaf only, is in entire concordance of characters with those of this species widely distributed in the Miocene of Europe.

HABITAT.—South Park, *Capt. Ed. Berthoud*.

23. FICUS OVALIS, *sp. nov*.

The only leaf repeseuting this species is coriaceous, oval, entire, narrowing in a curve to a long thick or flat broad petiole, grooved in the middle penninerv; lateral vein alternate, camptodrome, curving along the borders in festoons; tertiary veins short; areolation obsolete. The upper part of the leaf is broken.

HABITAT.—Pleasant Park, Plum Creek, *Dr. F. V. Hayden*.

24. FICUS PSEUDO-POPULUS, *sp. nov.*

Leaves oval-pointed, narrowed to the petiole, entire, three-nerved from the top of the petiole; lateral veins at an acute angle of divergence, like the secondary veins, two or three pairs, the lower of which is at a great distance from the primary ones, camptodrome; nervilles distinct, in right angle to the midrib, crossed by oblique branchlets, forming a large equilateral or polygonal areolation. A remarkable species,

resembling a *Cinnamomum* by the nervation of its leaves and a *Zizyphus* by the form.

HABITAT.—Evanston, *Dr. F. V. Hayden*.

T 25. FICUS WYOMINGIANA, *sp. nov.*

May be a variety of the former, resembling it closely by the form of the entire, long-petioled leaf. The difference is marked, however, by the total absence of secondary veins; the middle nerve being joined to the lateral ones by strong nervilles in right angle.

HABITAT.—West of Green River station, *Dr. F. V. Hayden*.

K 26. DIOSPYROS? FICOIDEA, *sp. nov.*

Leaf ovate, narrowed to a point (broken), rounded to the petiole, thickish, entire, pinnately-nerved; midrib thick, deeply marked, as also the secondary veins, parallel, at an acute angle of divergence, all doubly camptodrome; fibrillæ thick, nearly in right angle to the veins, divided in the middle; areolation square or polygonal; surface rough. The generic relation of these leaves is not satisfactorily fixed.

HABITAT.—Black Butte.

K 27. VIBURNUM PLATANOIDES, *sp. nov.*

This species essentially differs from *Viburnum marginatum* by the less numerous, more open, lateral veins, whose branches are more curved in passing up to the borders, and especially by the enlarged truncate or subtruncate base of the leaves. The direction of the veins along the lower branches of the lateral veins is the same, and the borders are dentate in the same manner, though not black-margined as in *V. marginatum*.

HABITAT.—Black Butte, mixed with Saurian bones, and as abundant in that bed as is its congener, in the shale above the main coal of the same locality.

T 28. CISSUS PAROTTIÆFOLIA, *sp. nov.*

Leaves ovate-subcordate or narrowed to the base, gradually and obtusely pointed, undulato-crenate, three-nerved from the top of the petiole or from a little above the border-base; lower secondary veins at a distance from the primary ones, which are much divided; all the branches, like the secondary veins, craspedodrome; nervilles strong, in right angle to the veins; areolation small, square, by subdivision of veinlets.

The species is represented by a few leaves, one of them, fragmentary, has a cordate, unequal base, and may belong to a different species.

HABITAT.—Green River, west of the station, *Dr. F. V. Hayden*.

K 29. RHAMNUS ROSSMÄSSLERI?, Heer.

Leaves oblong-obovate, obtusely pointed, entire, narrowed to the base, penninerve; secondary veins close, parallel, passing to the borders nearly straight and curving along them in festoons. These leaves are small; one only is preserved entire; their specific relation is not fixed.

HABITAT.—Black Butte.

T 30. PHASEOLITES JUGLANDINUS?, Heer.

Leaflets of an apparently compound leaf, oval-oblong, obtusely pointed, rounded to a short petiole, entire, subcoriaceous, penninerve; lateral veins parallel, distinctly camptodrome, and following the borders in festoons; ultimate areolation small, irregularly quadrate.

The species may be different from the European one bearing this name, but it appears to differ only by more open secondary veins.

HABITAT.—Green River group, near mouth of White River, *Prof. Wm. Denton.*

31. LEGUMINOSITES ALTERNANS, *sp. nov.*

Leaflet lanceolate, narrowed to the sessile base (point broken), apparently tapering and acute; borders entire; secondary veins close, numerous, fifteen pairs in a space of two and a half centimeters, with intermediate shorter tertiary veins anastomosing by crossing veinlets; areolation obsolete. This leaf is comparable to a *Dalbergia* or a *Podogonium* by its nervation; its form, especially the narrowed base, is comparable to *Cassia.*

HABITAT.—Near mouth of White River, *Prof. W. Denton.*

32. SAPINDUS DENTONI, *sp. nov.*

Leaves lanceolote, gradually narrowed to a long acumen, unequilateral and rounded at base to a short petiole, entire or slightly undulate, thick; secondary veins close, parallel, diverging forty to fifty degrees, thick, straight to the borders, where they abruptly curve, and which they closely follow.

Species allied to *Sapindus falcifolius*, Heer, but remarkably distinct from this and other congeners by the thick, close, lateral veins straight to the borders, where they curve so abruptly that they appear at first sight as craspedodrome. The areolation is of the same character as that of *S. falcifolius.*

HABITAT.—Green River group, near mouth of White River, *Prof. W. Denton.*

33. LOMATIA MICROPHYLLA, *sp. nov.*

Leaves very small, thick, coriaceous, linear-lanceolate, gradually narrowed to a point, and in the same degree to the base; secondary veins simple, thin, in an open angle of divergence, connected to a marginal vein. We have two leaves of this fine species. It is comparable to *Lomatia firma*, Heer, of the Baltic flora, but very small and thick; the surface mostly covered by a coating of coaly matter.

HABITAT.—Same locality as the former, *Prof. W. Denton.*

A large number of fruits and seeds, considered under the name of *Palmacites*, *Carpolites*, etc., have been figured for the Lignitic Flora. As the characters of these organs cannot be represented by mere description, they are not mentioned in this short synopsis.

A REVIEW OF THE CRETACEOUS FLORA OF NORTH AMERICA.

§ 1.—GENERAL REMARKS.

The formation known under the name of Dakota group is positively determined as Cretaceous by the animal-remains profusely embedded into the strata overlying it. This fact has been repeatedly and clearly exposed in the former reports of Dr. F. V. Hayden. As this formation rests immediately upon thick limestone beds of Permian age, its flora, which is mostly represented by dicotyledonous leaves, has apparently no ancestors in this country. In Europe, the dicotyledonous plants of the Cretaceous epoch are scarcely known, or, at least, they have not yet been satisfactorily studied and described. The more recent and important publication on the subject refers to the Cretaceous of Greenland, and exposes the specific characters of a proportionally large number of Cryptogams and Gymnosperms, Ferns, Conifers, Cycads, with few Dicotyledonous. Three of these only are represented in the flora of the Dakota group. There is, therefore, from antecedents or from contemporaneous floras, no points of comparison to which the character of the plants of this group might be referred. For analogies, we have to look to species described from more recent epochs. And, in these researches, the paleontologist is met with another kind of difficulty. The strata where the dicotyledonous leaves are found in Kansas, Nebraska, Dakota, &c., are separated from the Lignitic-Tertiary formations by a few thousand feet of measures, mostly shale and sandstone, all of marine origin, with animal fossil-remains denoting an uninterrupted series of Cretaceous types. These strata are generally overlaid by heavy beach-sandstone locally interspersed with fucoidal remains, extremely abundant in some places, or with a mass of crushed, half-pulverized fragments of land-plants. Over this, the Lignite beds come to view, with their accompanying shales and sandstones, wherein vegetable remains are found sometimes in profusion and in a beautiful state of preservation. Here, then, we should expect to recognize forms of leaves or species, if not identical with those of the Dakota group, at least showing, as probable offsprings, some affinity of characters with them. This as yet is not the case. The typical forms of leaves of the North American Cretaceous are not at all repeated in the Lower Lignitic flora of the Rocky Mountains, not more than they are in the Lower Eocene of Europe. With the exception, however, of the peculiar type of oak and chestnut, *Dryophyllum*, which originates in the Middle Cretaceous of both continents, is recognized in species of the Lower Eocene of France, Sezane and Gelinden, as in that of Point of Rocks, in Wyoming, and leaving some of its representatives in all the geological series, passes to the flora of our time. Some few more leaves of the Dakota group have a relation to species of Evanston, especially to those of Miocene of Carbon, in the same proportion, about, as they have to Miocene species of Europe; more still are closely allied to species of the Pliocene of California; but the analogies become far more evident and marked, also, by

more numerous points of similarity, in the present vegetation of the Atlantic slope of North America.

This absence of related forms in the nearest geological series of the Cretaceous, the re-appearance, also, of Cretaceous types in more recent formations, and especially at this time, are perplexing, indeed, to the querist, surrounding the study of this flora with a great deal of uncertainty and of difficulty. Who can believe that the dicotyledonous plants, which were destined to take such an immense predominance in the vegetation of the world, were, from the beginning, the same as they are now? How suppose that, after their exclusion from the floras of long geological epochs, a number of them have re-appeared anew, with their original characters? This would seem an anomaly, in contradiction to what is known, or, rather, generally admitted in regard to the succession, the multiplication, and the improvement of types, in following the ascending grade of the vegetable reign in its development. Do we not mistake in recording, as evident and close points of affinity, what may be mere illusional appearances? Questions of this kind give to the study of the North American Cretaceous flora a higher degree of importance, but, at the same time, force the paleontologist, who is trying to decipher the hieroglyphic records of the old floras, to pursue his researches with the greatest caution, reviewing again and again the forms which he considers as specific, comparing them from as large a number of specimens as may be obtainable, especially studying their relations with the vegetable contemporaneous types recognized in the same formations, or in those of another country. This renders the acquisition and the study of new materials constantly desirable, and, therefore, subject the conclusions arrived at to possible modifications. For this reason, the first volume of the Cretaceous flora of the Dakota group should be considered as an incomplete memorial, to which successive supplements have to be added by every one who, engaged in paleontological researches, is in position to get specimens of fossil plants from this group. The present review is one of these supplements, demanded for the reasons alluded above; first, by the discoveries in the Cretaceous formations of new and important materials, modifying, by their characters, generic divisions fixed from insufficient specimens, or adding new species or new types to those which were already known; and, secondly, by the critical notices of learned friends, at home and abroad, who, sensible to the importance of the data offered to science by the first exposition of the flora of the Dakota group, have urged me to pursue the work merely begun, and to bring forth, without delay, the results obtained by these new researches.

There is, however, still another and more forcible inducement to review successively the data procured by new researches and discoveries, in addition to our knowledge of the North American Cretaceous flora. It is the insufficiency of the materials obtainable for the comparison and the determination of specimens of fossil plants in this country. Messrs. Debey and Ettinghausen began the study of the Cretaceous flora of Belgium already in 1843. After spending a few years in exploring the Cretaceous formation in its geological and stratigraphical distribution and in collecting specimens, having, as they supposed, about three hundred species to analyze, they published, in 1848, an abridged synopsis or general review of the Cretaceous flora of Belgium, describing then only a new genus of Conifers, and a few species referable to it.* In 1849 they still published, as

* Ubersicht der urweltlichen Pflanzenreste des Kreidegebirges überhaupt, und der Aachener Kreideschichten im Besonderen, in Verh. des nat. Vereines d. preus. Rheinlande, 1848.

evidence of the progress of their researches, a catalogue, names only, of seventy species of their Belgian Cretaceous plants. But after they had enlarged their collection of specimens, and pursued their work of comparison, they were soon called to review their first determinations and to acknowledge that very few of their former specifications could be preserved, as they had to unite in one species a number of forms which were first considered as different, or to separate some others which they had formerly admitted as identical. In 1850 the great herbarium of the Botanical Garden of London was opened to them, and they had free access to the immense materials, especially exotic species of plants of the present time, which they wished to have for comparing the vegetable forms of the Cretaceous. In 1851 the celebrated authors published another short general review of the Cretaceous flora of Maestrich. These were merely introductory memoirs to the work which they had undertaken, and for which they acknowledge the assistance received, not only by direct communications of the greatest botanists and paleontologists of the time, Brongniart, Decaisne, Hooker, &c., but also by the free use of the largest botanical and paleontological collections of Europe, and of scientific libraries, where they could study, from its origin, the literature referable to vegetable paleontology; all the papers, even the most unimportant, which have been published on the subject. It was only, in 1859, and after nearly fifteen years of study, that the first and second parts of their work were published. The first, concerning the Thallophytes, describes and represents, in three plates, eighteen species of Fucoids, or marine plants, four species of Fungi, and one Lichen. The second part, on the Acrobriæ, describes, with figures, forty-one species of Ferns, and two species of doubtful relation to this family. Since then nothing more of this work has been published, and we know the dicotyledonous leaves, whose remains are said to abound in the Belgian Cretaceous formation, merely by some generalities related to their classification and a few generic names.

The work of the European authors is certainly of the highest scientific order, and might be taken as a model to be followed for proceeding in paleontological researches in our country. But who could work ten to fifteen years in preparing the publication of a report, when in his researches a naturalist does not find any materials for comparison. We have, as yet, no valuable collections in vegetable paleontology, and it is especially because the first materials have to be carefully prepared for institutions of this kind, that the paleontologist is called to review and correct his determinations as fast as new materials are prepared for examination.

The plants of the Dakota group, as known mostly by detached leaves, are striking by the beauty, the elegance, the variety of their forms, and of their size. In all this they are fully comparable to those of any geological epoch as well as to those of our time. From entirely developed leaves, less than one inch in size, they show all the gradations of size to one foot, even to one foot and one-half in diameter. The multiplicity of forms recognized for a single species is quite as marked as it might be upon any tree of our forests. And to expose the admirable elegance of their forms, it suffices to say that, at first sight, they forcibly recall those of the most admired species of our time: the tulip-tree, the magnolia, the sassafras, the sweet-gum, the plane-tree, the beach, the aralia, &c. The leaves of *Protophyllum Sternbergii* have the size and the facies of those of the catalpa, one of our finest ornamental trees. Those of *Menispermites obtusiloba*, of *Protospermum quadratum*, represent in the same manner some of the rarest shrubs, *Menispermum*,

Ferdinandia, &c., carefully raised in conservatories for the graceful forms of their leaves or the richness of their vegetation. It is indeed the first impression received from the beauty of forms of the leaves of the North American Cretaceous, and the evident likeness of their facies to that of the finest vegetable types of our time as we see them around us, which strikes the paleontologist and may lead him into error, in forcing upon the mind the belief of a typical identity where, possibly, there may be a mere likeness of outlines, a casual similarity of forms in the leaves. For, really, when we enter into a more detailed analysis of these Cretaceous leaves, we are by and by forcibly impressed by the strangeness of the characters of some of them, which seem at variance with any of those recognized anywhere in the floras of our time, and unobserved also in those of the geological intermediate periods. Not less surprised are we to see united in a single leaf, or species, characters which are now generally found separated in far distant families of plants. The leaves of *Eremophyllum*, so striking by the peculiar appendages of their borders; those of *Anomophyllum*, referable to planes by one half, to oaks by the other; those of *Platanus obtusiloba*, half *Acer*, &c., are of this kind. On another side, the characters of some of the Cretaceous species are sometimes of such a transient or indefinite order that it is scarcely possible to take hold of them and to expose them with a degree of reliance. At first sight they seem very distinct, but, in comparing a number of specimens, the differences dwindle by unmistakable transitions, and disappear. In other leaves, on the contrary, visibly identical by their outlines, the nervation is so different that they are forcibly separated and referred to far distant generic divisions. Hence, this flora does not leave any satisfaction, any rest, to the mind. Even the most clearly defined types become doubtful in regard to their integrity when we see others, which at first were recognized as positively fixed, manifesting instability and pointing to diversity of relations by the discovery of new specimens. The leaves considered first as Sassafras seemed evidently referable to this genus; but when leaves of the same type were found with dentate borders, though bearing besides all the characters of a genus which belongs to the *Laurineæ*, a family where, as yet, no representative has been found with dentate borders of leaves; when others were obtained with subdivision of the lower lobes in two or three, thus showing the palmate shape of *Aralia* leaves, the confidence in the value of the characters at first recognized had to be abandoned.

This revision bears, therefore, on the degree of relation, or of generic identity, which may exist between the leaves of the Dakota group and species of plants living at our time in this country or described from intermediate geological periods; on the degree of persistence in the characters which have been, or should be, considered as specific in the determination of these leaves; on the essential types of the Cretaceous flora considered as original, derived, or ancestors. These questions cannot be examined in the order where they are presented above; but they may be touched upon, as far as opportunity is offered, in remarking upon the different vegetable groups represented in this flora.

It is remarkable that though the Dakota group formation is recognized as marine by the presence of marine fossil mollusks, no remains of marine plants have been to this time found in any part of its strata. Divers reasons may be suggested in explanation of this fact; the coarseness of the matrix, for example, wherein the vegetable fragments were imbedded, and where mere cellular and soft plants could not be preserved. The fossilization of the leaves in the red ferruginous shale of

the Dakota group is not a true petrification. The forms or casts only are left after the total destruction of the substance. This may explain how most of the leaves which have been obtained from this group of the Cretaceous are of a coarse, thick, coriaceous texture. The delicate organs of plants, like thin leaves or sea-weeds, may therefore have been totally destroyed. If it is so, we know from this flora a part only, the one which is represented by leaves of a hard tissue and by some fruits and stems. At different places and horizons of the formation, especially near the upper part and at the base of the measures, one finds thin beds of black, plastic, soft clay, where remains of plants could be preserved in their integrity even with the epidermis of the leaves.. A single leaf has been found of that kind near Sioux City; it is referable to one of the species most commonly represented in the red shale, and therefore does not afford any point of comparison. The other deposits of clay have been found either barren of vegetable remains of any kind, or, also near Sioux City, mixed with decomposed, undeterminable fragments, especially of leaves of Conifers and of rootlets of water-plants, As it is the case in the red shales of the other formation to which this one has been compared—the Upper Devonian, the Lower Permian *—thin layers of coal or coaly matter have been deposited here and there in the so-called sandstones of the Dakota group. They are no coal-beds, however, but mere attempts or premises, and preparatian also, of a future Carboniferous formation. In the strata related as synchronous to the Dakota group, in Canada, New Mexico, New Jersey, &c., no workable coal-bed has been discovered till now. Some, which may be compared to the subconglomerate coal-beds of the Carboniferous, have been apparently formed near the end of the Cretaceous epoch. As yet, their fossil flora is unknown. In connection with the thin layers of coaly matter in the shale of the Dakota group, no specimen of fossil plants has been discovered till now.

Toward the end of the period of the Dakota group and in the upper beds of the formation a rapid succession in the elements of the compounds, mixed in various ways, in the size of the *débris*, etc, indicates a new influence, the introduction of deep marine water by slow submersion or subsidence of the land. It is after this, or in the Niobrara group, that the only species of marine plant described in the Cretaceous flora has been found. This *Zonarites digitatus*,† though similar in its character to the species published under this name by Brongniart and Geinitz, has its relation contradicted by the great difference between the geological periods where the remains have been found in Europe and in America, and still more perhaps by the difficulty of identification of marine plants whose characters are represented merely by a vague likeness of outlines. It would have been advisable, perhaps, to leave out without description a vegetable of that kind, not even referable to the Dakota group, and to leave also without even a mention mere fragments like those described as *Ligodium trichomanoides*, *Abietites Haydenii*, *Flabellaria minima*, etc., whose characters and relation are too vaguely indicated. But as the Cretaceous plants of this and other countries are scarcely known, it seemed proper to represent by drawing all the discernible fragments, leaving to time an opportunity of confirming or refuting by better specimens the first determination. Even small fragments may become valuable as complement of other specimens which, fragmentary also, may be defined by those which have been published before, and which, for the same reason of defectiveness, should be left

* Cretaceous flora in Dr. F. V. Hayden's Report, vol. vi, pp. 26, 27.
† Cretaceous Flora, p. 44, Pl. I, Fig. 1.

aside as rubbish. *Anemidium Schimperi*, *Sphenopteris grevillioides*, etc., of the Cretaceous Arctic flora of Heer, are not more subject to satisfactory determination than *Lygodium trichomanoides* or *Pterophyllum Haydenii*. Moreover, this last species, though imperfectly represented, indicates a point of relation between the Dakota group flora and that of the Cretaceous (*Quadersandstein*) of the Hartz Mountains in Germany. Fragments of this kind are, therefore, doubly interesting by botanical and geological affinities.

Before entering farther into the discussion and comparison of generic and specific types of the North American Cretaceous flora and of their relation with vegetable forms described from Cretaceous formation of other countries, I have to add a few remarks more on the third volume of the Arctic flora of Heer, which was in publication at the same time as that of the flora of the Dakota group, and of which I could give only a short mention (p. 40), from a general synopsis formerly published by the celebrated author. The Cretaceous flora of Greenland, which constitutes the essential part of this third volume,* is in two parts. The first describes seventy-five species from four different localities of the north side of the peninsula of Noursoak, North Greenland, representing a lower stage of the Cretaceous. Of these, thirty-eight belong to Ferns,† four to Lycopods and Equiseta, eight to Cicadeæ, seventeen to Conifers, six to Monocotyledons, and one to Dicotyledons. This flora is, therefore, composed of fifty-six per cent. of Acrogens, Ferns, Lycopods, and Equiseta; twelve per cent. of Cycadeæ; twenty-two per cent. of Conifers; eight per cent. of Monocotyledons; and one per cent. of Dicotyledons. In the Ferns, the genera *Asplenium*, *Pecopteris*, *Gleichenia*, are predominant, this last genus especially, which is represented by thirteen species. In the Cicadeæ, the Zamites, five species; in the Conifers, the *Sequoia* and *Pinus*, the first with five species, the second with four.

The second part of the Greenland Cretaceous flora describes remains of plants, especially found in the southern part of the same peninsula. Considered as Upper Cretaceous by the author, it has in sixty-two species, thirteen Ferns, two Cycadeæ, ten Conifers, three Monocotyledons, and thirty-four Dicotyledons. The relative proportion of these plants is therefore far different, as here, fifty-five per cent. are Dicotyledons. In regard to their generic distribution the predominance is marked, in the Ferns by *Pecopteris* and *Gleichenia*, in the Conifers by *Sequoia* and *Pinus*, and by *Populus*, *Proteoides*, *Chondrophyllum*, and *Magnolia*, in the Dicotyledons. And in considering the general character of the land vegetation of North Greenland, at the Cretaceous epoch, and as far as it is known for the present by counting together the species of both stations, we find it represented by a percentage of thirty-seven for the Ferns, three for the Lycopodiaceæ and Equisetaceæ, eight for the Cycadeæ, nineteen for the Conifers, six and a half for the Monocotyledons, and twenty five for the Dicotyledons, which therefore represent only one-fourth of the whole.

The first exposition of the Dakota group flora shows four species of Ferns and six species of Conifers only. To this small number we have

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* A number of the Cretaceous plants of Cape Staratschin, Spitzberg, are also described in this work. They represent five Ferns, one Equisetum, nine Conifers, and one Monocotyledon, or sixteen species. The predominance of Conifers is remarkable as well as the absence of Cycadeæ and of Dicotyledons. Of these species, three Ferns and three Conifers are identified with the lower Greenland flora, and five Conifers with the upper, indicating an equal relation to both or an intermediate geological station.

† By a misprint in the above exposition given in Cret. Flora, p. 40, the word Fucoids is written for Ferns.

added in this review one species of *Gleichenia* and five species of Conifers. The specific value of some of the vegetable remains referable to this last family is, however, doubtful, especially for those which are represented by cones only, *Abietites Ernestinæ*, *Sequoia formosa*, *Sequoia Reichenbachi*, and the fragments described as *Inolepis*, all which, however, though uncertain their specific or generic relation may be, are evidently representatives of some species of Conifers. The fragments referable to this group are of a difficult determination; for the organs represented upon the coarse shale or hard ferruginous sandstone of the formation, merely expose some outlines of their forms by the same kind of fossilization or molding, remarked already for the leaves. We do not find, therefore, any flattened cones with the scales, any flattened branches with leaves, but impressions only, more or less deeply carved into the stone, the cones even passing through the shales and showing the space originally occupied, as a mere cylindrical hollow, around which the forms of the scales are more or less clearly engraved. The numerous leaves of *Pinus* spread upon the surface have dug in the same way and by their hard substance, narrow linear channels, representing the back of these leaves, with an indistinct midrib, and the branchlets of *Sequoia* also are seen as longitudinal grooves, bearing on both sides the same impressed form of their leaves. This cannot be considered a very distinct representation of characters, the minute details desirable for an exact determination being more or less obsolete.

Among the specimens recently examined, a fragment has been found referable to *Phyllocladus*; the presence of this genus in the Cretaceous flora is thus sufficiently ascertained. We may, therefore, record as recognized in the flora of the Dakota group, for the Ferns, the genera *Lygodium*, *Sphenopteris*, *Hymenophyllum*, and *Gleichenia*, the three first by each one species, the last by two; and in the Conifers, *Sequoia*, by three species; *Pinus*, by one, and *Phyllocladus* by one, leaving out as of uncertain generic relation with the cones mentioned above, *Glyptostrobus* (?) *gracillimus*, which is perhaps identifiable with *Sequoia condita*, or with *Frenelites*, and *Geinitzia* (?), known merely by the impressions of some detached scales. To this should be added *Araucaria spatulata*, described in extinct floras of North America by Dr. Newberry, from Nebraska specimens.

A fine plant, doubtfully described with the Ferns in Cretaceous Flora, p. 48, Plate XXIX, figs. 1–4, under the name of *Todea* (?) *saportanea*, has to be eliminated from this family. For, though the shape of the leaflets, their mode of union to the rachis, the position of parallel equal branches are, by similarity, comparable to leaflets and to divisions of fronds of ferns, the areolation of the leaves, which has been studied from better specimens and figured here again, Pl. VI, fig. 2, more positively relates these vegetable fragments to a peculiar section of the *Proteaceæ* or to *Lomatia*, a genus especially represented in Australian Islands and on the southwestern coast of South America, Chili, and Peru. For this separation I readily submit to the opinions of learned friendly critics. But I cannot consider the glumaceous leaf and tubercle described as *Phragmites cretaceous* in Cret. Fl., p. 55, Pl. I, figs. 13, 14, and Pl. XXIX, fig. 7, as a species of *Dracæna* or *Yucca*, &c. The tubercle represented (fig. 13) is really similar to organs of the same kind found attached to Rhizomas and to stems of fossil *Phragmites* and *Arundo*. And for confirmation of the warranted reference of these fragments, we have now in *Arundo greenlandica*, Heer. Fl. Arct., VIII, p. 104, Pl. XXVIII, figs. 8–11, leaves which, though narrower, have the same form and the same characters of nervations as those of the Dakota

group. In the Kansas specimens only the epidermis of the leaf is destroyed at a few places where the veinlets become perceptible. Generally, however, as in the specimens of Greenland, the primary veins only can be seen.

Of the fragments doubtfully referred to *Flabellaria?* and described as *F. minima*, Cret. Fl., p. 56, Pl. XXX, fig. 19, nothing more has been discovered in regard to their relation, which has to be considered as unknown as yet. The same may be said of the peculiar vegetable form described in Cret. Fl., Pl. 1, fig. 6, as *Pterophyllum? Haydenii*, which was supposed to represent some kind of *Cicadeæ*. It differs from any species known of this family by the broad stem and short leaves, narrowed to the point of attachment, and from these characters Professor Heer thinks it referable to Conifers.

Now, counting the leaf described as *Dioscorea? cretacea*, whose generic reference may be doubted, but which evidently represent a species of the *Dioscoreæ* or a monocotyledonous, and also the fragments referable to Conifers in the description, we have to this time, in the flora of the Dakota group, and exclusively of the dicotyledonous, sixteen specific forms, representing the cryptogamous acrogens by five Ferns, the phœnogamous gymnosperms by nine Conifers, and the monocotyledonous by one glumaceous and one petaloid species.

The first dicotyledonous leaves described in the Cretaceous Flora, under the name of *Liquidambar integrifolium*, have been considered by some authors as uncertain in regard to their generic relation merely on account of their entire borders. The form of the leaves, however, especially as figured (Pl. II), with the lobes slightly enlarged above the sinuses, and then gradually narrowed to a slightly obtuse point, and the nervation also, have the same character as those of the living *Liquidambar styraciflua*. It is true that the four species of this genus known in the present flora have serrate borders of leaves. But three fossil species represented by leaves with entire borders have been described as *Liquidambar* from the Tertiary of Europe; and, though this reference is more or less hypothetical and controversed, it shows, however, that botanists of high standing—Unger, Watelet, Massalongo—have considered as probable, at least, the relation of leaves with entire borders to this genus. It is easily seen that the leaves of *Aralia Towneri*, described in this paper (Pl. IV, fig. 1), have a relation of shape or general outline to those of *Liquidambar integrifolium;* and this apparent similarity can but suggest the possible reference of all these and like forms to the genus *Aralia*. I may admit this reference as probable for the two leaves figured in Cret. Fl., Pl. XXIX, figs. 8 and 9, which are comparable, by their primary nervation, to those of *Aralia concreta*, sp. nov., Pl. IV, figs. 2 and 3. But though we have now a large number of specimens referable to divers araliaceous types, there is none as yet with leaves divided into lanceolate acute lobes like those which are figured in Pl. II, Cret. Fl. The reference of these leaves to *Sterculia* has been proposed also, from analogy of forms to some species of this genus. The presence of one well characterized species of *Sterculia* in the Cretaceous flora of New Jersey, where it is in connection with numerous leaves of *Magnolia alternans*, seems to give a kind of support to this proposition. But in this case, also, I find too evident a difference in the characters of nervation of the palmately-nerved leaves of *Sterculia* with those referred to *Liquidambar*. Even taking as evidence of possible affinities the distribution in the same formation of leaves referable to allied genera, we could just as well admit the presence of *Liquidambar* species in the Dakota group, by the reason that other forms of *Hamamelideæ*,

a family to which this genus belongs, are recognized in the same group. From these considerations, I persist in regarding as ancient, primitive, or derived representatives of a species of *Liquidambar* the fossil leaves described under this generic name, until other specimens, if any are found, may point, by a variation of characters, to another more evident relation.*

A number of vegetable remains of the Cretaceous are evidently referable, by their characters, to *Populus*. The only dicotyledonous leaves recognized by Heer, in the specimens which he studied from the Lower Cretaceous formations of Greenland, represent a *Populus*, appropriately specified by the name of *P. primæva*. From a higher stage of the same Cretaceous formation of that country, the celebrated Swiss paleontologist has described three other species of *Populus*. In his Phyllites Crétacées du Nebraska, and from specimens of the Dakota group, he has recognized *Populus litigiosa*, *Populus? debeyana*, and another species still, *P. cyclophylla*, described in the Proceedings of the Academy of Natural Sciences of Philadelphia. Professor Newberry, in his paper on the later extinct floras of North America, has described, also, besides the doubtful *P.? debeyana*, three new species: *Populus? cordifolia*, *P. elliptica*, and *P. microphilla*. The specification and the interrogative punctuation applied to some of these names show that the authors themselves do not consider the generic reference as definitive, the character of some of the leaves being somewhat in disaccord with those generally recognized in species of *Populus* of our present time. Indeed, species of this kind, like the present *P. alba*, for example, have such multiplied and diversified forms of leaves, such great variability in their nervation, the mode of attachment of the petiole, &c., that they readily offer, by comparison with fossil leaves of obscure relation, some points of affinity which, being not found elsewhere, have to be considered by the authors. Hence the doubtful references which may be, and are often rectified by subsequent discoveries, as is proved by the great proportion of synonyms appended to the enumeration of *Populus* species. To obviate this inconvenient multiplication of fluctuating species of *Populus*, I proposed a new generic division, under the name of *Populites*, for the classification of those Cretaceous leaves, numerous indeed, which, partaking of some of the characters of *Populus*, are nevertheless removed from this division by some others, as remarked in the memoir.† *Populus lancastriensis* was considered as a legitimate species of the genus, and in the new division were described *Populites elegans*, *P. ovata*, *P. quadrangularis*, *P. flabellata*, and *P. salisburiæfolia*, with *P. cyclophylla*, represented by leaves which I considered as answering to the description of this species by Heer.

This first memoir on some Cretaceous fossil plants from Nebraska had to be prepared, at a short notice, from a limited number of specimens. Since its publication, I have had opportunity to study the specific forms of this Cretaceous flora by comparing a very large number of specimens, and have thus recognized a more evident affinity of some of those leaves referred to *Populites* with other generic divisions. The only *Populites lancastriensis* and *P. elegans* which Schimper considers as a true *Populus* are preserved in this genus, while *Populites cyclophylla* and *P. ovata*, appearing rather related by their characters to the *Ampelideæ*, are described under a new generic division. The leaves represented by these species have, indeed, by their craspedodrome and subpalmate ner-

* Fragments of leaves closely allied to this form are described as Phyllites in Reuss, Verstein, Pl. LI, figs. 4 and 5.

† Am. Jour. Sci., vol. xlvi, July, 1868, p. 93.

vation, and by their base narrowed to the petiole, a more evident affinity to species of *Cissus*, or *Vitis*, than to those of *Populus*.

In regard to the distribution of *Populus*, to which is referred the most ancient dicotyledonous leaves known as yet, that of the Lower Cretaceous of Greenland, it has, as said above, three species known already in the Upper Cretaceous of that same country, and five or six in the Dakota group. It has, however, not been remarked in any Cretaceous flora of Europe. It is not mentioned in the review of the genera represented by the, as yet, undescribed species of Aix la Chapelle, and no form even distantly related is described in the Lower Paleocene flora of Gelinden. It has, however, one species in the Eocene flora of Sezane, and increases in the number of its representatives in all the stages of the Miocene. As far as we know it, till now, it has few species in our Lower or first American Tertiary group, the Eocene; a large proportion, eight per cent. of the species, in the second; still more, or twelve per cent., in the third; and is scarcely present in the fourth, the Green River group.

The presence of willows, species of *Salix*, in the flora of the Dakota group is not controverted; the reference of leaves by which the genus is represented in this formation is evident. As it is seen in Cretaceous Flora, p. 60, Pl. V, figs. 1–4, I have described as referable to one species only, a number of leaves somewhat different in their size and their shape. As the specimens representing them are from the same locality, and as I recognized upon some of them fragments of leaves with all differences of size, forms, and even consistence and color, I considered them as mere variations of leaves of a same tree. Dr. Newberry has from the same formation four species which, he says, he has chosen to regard as distinct, for geological convenience. No salix has been recognized as yet in any stage of the Cretaceous of Greenland; but one species, *Salix Hartigii*, Denk, is from the quader sandstein of Germany, and another, *Salix Goetziana*, Heer, from Quedlinburg. The genus is therefore sparingly represented in Europe and North America in Cretaceous floras which are considered as nearly synchronous. The other genera of the Amentaceæ, Betula, Alnus or Alnites, Myrica, Quercus, Fagus and Ficus, to which leaves have been referred in the Cretaceous Flora, do not require any observations. In this case, as in all the determinations of fossil plants, the characters of the species are not always satisfactorily established, but the generic affinities have been recognized or passed without any marked criticism. The generic relation is especially positive for the remains referable to Myrica, which was already represented in the Cretaceous Flora by one fragmentary leaf and by seeds, and to which a fine new species is added in this memoir. It seems equally so for Quercus or its peculiar division, *Dryophyllum*, of which we have two new species, and for *Ficus*, to which one species is added.

Specimens of leaves referable to *Platanus* have been found in moderate proportion both in Nebraska and Kansas. The first was described by Heer, in the "Phyllites du Nebraska," as *Platanus Newberryi*, from a very incomplete fragment. The accuracy of this determination was, however, subsequently testified by the discovery of more complete leaves figured in Cretaceous Flora, Pl. VIII, figs. 2 and 3, and Pl. IX, fig. 3, which show the narrowed base descending along the petiole lower than the point of union of lateral primary veins, and also the tendency to a three-lobed division, characters which were not observable in the fragment which Professor Heer had for his examination. To this fine species have been added: *Platanus primæva*, described from leaves so remarkably

similar to those of *P. aceroides*, of the Miocene, that I was at first disposed to consider them as identical; then, *P. Heerii*, rare, like the former, and found as yet only along the bluffs of the Salina River; *P. obtusiloba*, from a number of somewhat fragmentary specimens from Beatrice, Nebraska, all representing leaves of about the same size and of the same characters; *P. affinis*, *P. recurvata*, and *P. diminutiva*. All the species are described and figured in Cretaceous Flora. The last one as remarked in its description may be a dwarfed form of *P. primæva* or *P. Heerii*. The leaf appears as gnawed along the veins by insects or perhaps by a parasite fungus. Its specification is not positive and is subject to criticisms. The base of the leaf is rounded to the petiole, a character as yet unique for a species of this kind. *P. recurvata* should, following the opinion of my honored friend Count Saporta, be referred to the Aralicеæ by a more intimate affinity to *Araliopsis* species; and *Platanus affinis* seems now, after the examination and comparison of a number of specimens from Kansas, more evidently referable to the *Ampelideæ* than to the *Plataneæ*. Therefore these two last species are now eliminated from this generic division. I persist in considering *P. Heerii* and *Pl. obtusiloba* as two different species, though it has been suggested that the last was probably a mere variety of the first. The identity is denied not only by the facies, and the nervation of the leaves, but especially by the thinner texture of those of *P. obtusiloba*. The fact, that the numerous specimens representing it are all from the same place in Nebraska, and that *P. Heerii* has not been found in this State till now, confirms this separation. In regard to this last species, Professor Geinitz has remarked in the Isis, 1875, p. 558, that paleontologists might perhaps recognize in it a *Credneria*. There is some similarity in the general outline of the leaves, indeed. But this might be said of many of the generic forms of the Cretaceous, which seem to refer to a few different types, or to present in one leaf the characters which we now generally find isolated in separate vegetable groups. The genus *Credneria*, known as it is to me by what is described in the vol. V, of the Paleontographica, by Stiehler, includes species with cordate or subcordate leaves (none narrowed to the petiole), and bearing above the base two or three true secondary veins in right angle to the midrib. In *P. Heerii*, the leaves are cuneate to the base, even gradually narrowed or decurrent to the petiole, which thus becomes slightly winged, and the veins under the primary nerves are mere marginal veinlets. Perhaps the relation of this species is more marked to the genus *Ettinghausenia*, which, I regret to say, is scarcely known to me except by *Chondrophyllum grandidentatum*, as represented by Heer in the Cretaceous Flora of Moletin, and by *Phyllites repandus*, Sternb., two forms which have no affinity to *Platanus*.

In regard to its geological distribution, this genus is truly remarkable. No trace of it is recorded as yet in the Cretaceous of Europe, not even in the Paleocene and Eocene of France, so rich in fossil vegetable remains. Its first appearance in Europe is in the Upper Miocene of Oeningen, and of Austria and Italy, where it is represented by two very similar forms, *Platanus Guillelmæ* and *P. aceroides*. These two species are present in the same formation from the northern parts of the Arctic lands to Italy. It is followed in the Upper Tertiary or Pliocene of this last country by *Platanus Academiæ* Gaud, related as originator, perhaps, to the living *P. orientalis*. I have remarked above that the relation of leaves of the Dakota group to *Platanus* has been considered as doubtful by some European paleontologists. This doubt may have been induced by thè understanding of the total absence of *Platanus* leaves in the Cretaceous and Lower Tertiary of Europe. If so, it is cer-

tainly removed by the presence in our lignitic Eocene of some very beautiful and well characterized species of this genus: *Platanus Haydenii* and *P. Reynoldsii*, Newby. These species, discovered first in the Tertiary of the Upper Missouri River, near Fort Union, are predominant at Golden, Colo., by the number of specimens which represent them, and are also found at Black Butte. The third Tertiary group, that of Carbon, has, for the more numerous representatives of its flora, leaves of *Platanus Aceroides* and *Pl. Guillelmæ.* No species of this genus has been described from the Green River or fourth group; but we have from the Upper Tertiary (Pliocene) of California very fine specimens of leaves of two species of *Platanus* closely related by their characters to the living *Platanus occidentalis.* Therefore, and considering the geological records, we may trace the origin of *Platanus* as far down as the North American Cretaceous, and follow its development through nearly all the stages of the Tertiary to our present time, by a number of closely-allied intermediate forms.

Coming now to the *Laurineæ*, I have to remark somewhat more definitely on the Cretaceous species referred to this family. The relation of some of them to the genera to which they have been referred is generally acknowledged, and the presence of the *Laurineæ* in our Cretaceous flora receives a kind of historical authority by that of a Sassafras in a Cretaceous formation of Greenland; of three species of *Daphnophyllum* in that of Moletin, and of *Laurus cretacea*, *Daphnogene primigenia*, *Daphnites Göpperti*, in that of Niedershoena. Of the species which have been described formerly in the flora of the Dakota group, *Laurus Nebrascencis* is related to *Daphnophyllum ellipticum* and *D. crassinervium* of Heer, while *Cinnamomum* and *Oreodaphne cretacea* are comparable to *Daphnogene primigenia* of Ettinghausen. *Persea Sternbergii* is also evidently of the same family, and the two leaves, described here below under the name of *Laurus proteæfolia*, are indeed allied to species of *Laurus* or of *Persea* by their nervation, especially by the more acute angle of divergence of the lower veins, though they show in the grooved middle nerve a character often remarked in species of *Ficus*, especially *Ficus protogea* Heer, of the Greenland Cretaceous flora. Moreover, the fruit described (Fl. Cret., p. 74) as *Laurus macrocarpa* satisfactorily completes the evidence afforded by the leaves, of the existence of species of *Laurinæ* in the vegetable world of the Cretaceous epoch. We have, however, to eliminate of this family *Laurophyllum reticulatum*, which appears more properly referable to *Ficus.* Its nervation, and especially its areolation, formed of square or irregularly polygonal meshes by the interposition of tertiary veins between the secondary ones and parallel to them, and the rectangular subdivision of its branches, are of the same character as in *Ficus Geinitzi*, Ett., *Ficus protogea*, Heer, and many species of this genus now living in Cuba, even Florida, like *Ficus suffocans*, *F. lentiginosa*, *F. pertusa*, *F. dimidiata*, etc. Numerous specimens recently found in Kansas represent this fossil species in characters more precise than formerly, as seen in its more detailed description under the name of *Ficus laurophyllum.*

But if the reference of some of the above-mentioned leaves to the *Laurineæ* is not contested, it is not the same in regard to those which, at first appearance, were considered as more positively related to it, and which have been described under the generic name of Sassafras. The question of the relation of those leaves which, by their number, seem to be the essential components of the North American Cretaceous flora, has been already touched upon.* But since, I have obtained

* Cretaceous Flora, p. 77.

from divers localities a large number of specimens representing all the forms described as species in the same work, and I have now some more data to offer to the consideration of paleontologists on the subject. From historical documents the presence of Sassafras species in the flora of the Dakota group is as legitimately presumable as that of species of Laurus or Persea. In his Flora Arctica, Heer has described as *Sassafras arctica* a leaf which, by its form, is similar to those described as *Sassafras cretaceum*, as remarked by the author, differing merely by its base somewhat less narrowly tapering to the petiole. The nervation is of the same character. Count Saporta considers this Greenland leaf as a true representative of Sassafras. He has himself published in the Sezane Flora,* as *S. primigenium*, two fragmentary leaves whose base, more narrowly tapering, is similar to that of our *S. Mudgei*, as well as the lobes which, enlarged in the middle, have that ovate-lanceolate shape so distinctly marked in the present *S. officinale*. There is also no appreciable difference in the nervation. The lower secondary veins of the middle lobe ascend a little higher in the leaves of the Sezane flora, and unite with those of the lateral lobes somewhat nearer the borders of the sinuses. But in some of the specimens of Kansas the same appearance is remarked also, and the difference between the more or less distance which separate from the sinuses the branch which unites the upper division of the secondary veins, is observable upon leaves of *S. officinale*, this vein being sometimes marginal, sometimes curving one to three millimeters lower than the border of the sinuses. Comparing leaves of *Sassafras officinale* with those represented by Count Saporta in the Flora of Sezane and the specimens of *S. Mudgei* from Kansas, it is impossible for me to recognize any character, even any specific difference by which these leaves could be separated. It is, therefore, not surprising that Dr. Newberry first, and after him Heer and Schimper, did consider Cretaceous specimens of this kind as representing species of Sassafras. In the last volume of his superb work on Vegetable Paleontology,† Prof. W. P. Schimper, speaking of leaves of *Sassafras cretaceum*, of which I had sent him photographical designs, remarks, "That those leaves, very variable in size, present such a remarkable likeness to those of *S. officinale*, now living in North America, that one would be disposed to consider them as belonging to an homologous species." He rightly adds that the only difference seems to be in the thicker substance of the fossil leaves. Even on this point I have from Texas specimens of the present *S. cretaceous*, whose leaves appear of a consistence nearly as thick as those of the Dakota group seem to have been.

But now, and on another side, no species of the *Laurineæ* family living at our time is known with dentate leaves; and it may be remarked, from the figures, that the two leaves described as *Sassafras Cretaceum* (Cret. Flor., Pl. XI, figs. 1 and 2) have the borders of the lobes somewhat dentate, and some of the secondary veins running into the point of the teeth or craspedodrome. This character is still more marked in *S. mirabile*, loc. cit., Pl. XII, fig. 1, a form extremely common in Southern Kansas, and represented in very numerous and remarkable varieties. In some of the leaves the secondary veins are all camptodrome, and therefore the borders of the lobes are entire. In others, as seen, Pl. XI, fig. 2, the outside lateral veins are craspedodrome, and thus the borders dentate, while on the inside they curve along the borders, which are entire.

* P. 366, Tab. VIII, figs. 9 and 10.

† Traité de Paleontologie végétale, vol. iii, p. 598.

In the fine complete leaf, fig. 1 of the same plate, the middle lobe has the veins all camptodrome on the left side, while on the right one a few of them, one or two, reach to the border, which has, therefore, one or two short undistinct teeth, and the lateral lobes are clearly dentate on the outside only. This evidently shows such a disposition to variations of nervation and border divisions, that I did formerly consider as unjustifiable a specific, and still more a generic division between the leaves of Pl. XI, figs. 1 and 2, and those of Pl. XII, figs. 2 and 3, of the Cret. Flora. When, therefore, we find the same differences between the leaves which represent *S. mirabile*, Pl. XII, fig. 1, it seems that the same conclusion should follow. But in this case, with the more generally predominant character of the indentation of the leaves, which, in some larger specimens than the one figured, are more deeply cut by divisions, like pointed lobes, there is still another one, remarked on a specimen recently discovered, which seems to more forcibly separate these forms from the *Laurineæ*, and indicates a more evident relation to the *Araliaceæ*. The specimen communicated by M. Chs. Sternberg, to whose careful and zealous researches the flora of the Dakota group is indebted for many important discoveries, represents a large leaf which, by its outlines, the nervation, and the dentate borders of its lobes, is exactly like our *S. mirabile* of Pl. XII, fig. 1. The leaf, which is much larger, however, the lobes measuring ten centimeters in length from the point of union of the primary nerves, greatly differs by the forking of the lateral nerves, from a point two and one-half centimeters above their base, and thus forming, of course, a subdivision of these lobes into two equal parts, or a palmately five-lobed leaf. Among the innumerable varieties in the shape of the leaves of the living *Sassafras officinale*, we see a constant and gradual mode of division passing from a round or oval and entire shape to a bilobed and trilobed one; but, as yet, I have been unable to observe a single case of subdivision of the lateral lobes, or to find a palmately five-lobed Sassafras leaf. This character is, on the contrary, far more generally seen in the *Araliaceæ* of our time than in the trilobate form of Sassafras. But in this section of *Araliaceæ*, the *Hedera*, which may be compared to our leaves, I do not know any with trilobate leaves. *Hedera turbascens*, *H. discolor*, *H. argentea*, *H. aurifolia*, *H. jatropæfolia*, have leaves five to seven palmately lobed, or, when occasionally trifid, their segments are narrow and acuminate, of a type related to that of *Aralia tripartita* of Pl. I, fig. 1, of the memoir. The reference of these leaves to *Araliaceæ* is, therefore, apparently obscure or uncertain. And still, on another side, comparing the beautiful *Aralia saportanea* represented in this memoir, fig. 2 of the same plate, we see in its nervation, as well as in the indentation of the borders, &c., a remarkable identity of characters with those of the five-lobate leaf of *Araliopsis mirabilis*. Thus we have about the same degree of evidence in regard to the relation of these fossil leaves to Aralia or to Sassafras.

Going further into this kind of investigation, we are met by a new difficulty in the appearance of another modification in the characters of this peculiar type of leaves. In examining the first specimens of the species represented, Pl. II, fig. 1, I could but consider them as representing either *Sassafras* (*Araliopsis*) *obtusum*, or *S. mirabile*, for, the specimens being fragmentary, had only the lobes or part of them. As long as the auricled and peltate base was unknown, the reference of the specimen could not be different. The nervation, the form of the lobes, their size, all is of the same character as in *S. mirabile*. But in the peltate base of the leaves, which is figured from a leaf preserved entire, Pl. II, fig. 1, and from fragment of much larger ones,

fig. 2, we have another character which presents the union of leaves of this kind either with the *Laurineæ* or with the *Araliacea*, and thus it is necessary to admit a third generic division for the classification of the vegetable remains of this new and remarkable type, which adds to its affinity to Sassafras and Aralia a character which relates it to Platanus and Credneria, by the basilar appendage of the leaves and its nervation. We have thus already in those leaves Sassafras, represented by *S. Mudgei*, and less positively by *S. acutilobum*, *S. cretaceum*, and *S. cretaceum* var. *obtusum*, which, as seen by the description, has to be considered as a specific form. To *Araliopsis* are referable *S. mirabile*, with the dentate *S. cretaceum* and *Platanus recurvata;* and to the new generic division, under the name of *Aspidiophyllum*, those leaves which, either Aralia or Sassafras by their upper trilobate part, are forcibly separated from these genera by their auricled peltate appendage. Still, the subdivisions in the classification of these peculiar and so-called Sassafras leaves, have to be pursued farther, for by degree and by the gradual obliteration of their lobes, they become round or truncate, or broadly pointed at the top, preserving more or less the narrowed base, tapering to a long petiole, and the trifid craspedodrome nervation from a distance above the borders, and thus they become more evidently related to other vegetable orders. One species is a true *Hedera*, another goes to the *Hamamelideæ*, and a number have their affinity with the *Ampelideæ*.

The characters of the leaves of this order, especially those of Cissus, are somewhat obscurely represented in *Sassafras Harkerianum*, Cret. Flor., Pl. XI, figs. 3 and 4; Pl. XXVII, fig. 2, and in *S. obtusum*, Pl. XIII, figs. 2 to 4; more distinctly in *Cissites acuminatus*, Pl. VIII, fig. 1; and *C. Heerii*, Pl. VI, fig. 3, two new species described in this memoir. They appear to constitute an indivisible group with the two former ones. Some of the leaves formerly described as *Populites* are also referable to this section, or to another less exactly defined; *Ampelophyllum*, allied by some of its characters to *Hedera*, by others to *Credneria;* thus intermediate to the *Ampelidæ* or the *Tiliaceæ;* by the areolation to *Greviopsis*, and also more distantly to *Chondrophyllum* of Heer, as remarked in the description. From this it is perceivable that this Sassafras type, which at the beginning was regarded as simple, well defined, and limited in its character, is, on the contrary, multiple and representing forms which, as far as the researches increase the discoveries, indicate affinity to a number of different genera or orders of the vegetable reign. Considering for example *Sassafras acutifolium* of Cret. Flor., Pl. XIV, which, from specimens representing intermediate forms between fig. 3 and fig. 4, I was disposed to consider as a mere variety of *S. Mudgei*, and passing to fig. 7 of Pl. XXX, evidently of the same generic type, and then to fig. 1 of Pl. VIII of this memoir, where is the difference or the point of separation to be marked? The type of *Ampelidæ* is quite as distinct as that of the *Araliaceæ* in this peculiar group; but both are recognized it seems merely in the extreme and opposed limits of their modifications.

The same remark is applicable just as well to the leaves which have been described in the Cret. Flora under the generic name of *Protophyllum*. The disagreement in the affinities of its species has been exposed in the remarks following the description of the genus. I have now to add still to this division two leaves recently communicated from Kansas, represented, Pl. III, fig. 1, and Pl. VIII, fig. 4. They fully confirm the former observations. By the outline of the leaves, their craspedodrome nervation, and the presence of two pairs of secondary veins

under the primary ones and in right angle to the midrib, they represent a species of *Protophyllum;* but the border base of the leaves is truncate, not subpeltate, and by this difference the leaves are rather referable to *Credneria*, from which, however, they differ by the veins all craspedodrome as well as their divisions, and by the truncate, not cordate, base of the leaves. I have formerly published a short description of these leaves under the name of *Credneria ? microphylla*. It now seems that by their evident relation to *Protophyllum quadratum*, they have to be admitted in the generic division, an opinion which may be put at naught by the discovery of specimens pointing to another reference for these leaves.

We have, also, an addition of three new species to the group of Cretaceous plants described under the genericname of *Menispermites*. In this case, however, there is no difficulty whatever in conformably uniting into a definite group the characters of the leaves which, round, ovate, or oval, with borders entire or undulate, have a common generic affinity, indicated by their nervation. In order to more clearly bring into view the relation of the undulate-lobed forms of leaves described in Cret. Flora, Pl. XX, figs. 1–4, and Pl. XXV, fig. 1, I have represented, Pl. VII, fig. 3, of this paper, a finely and wholly preserved leaf of *Menispermites obtusiloba*, which, though small, is easily identified with the large one of Pl. XXV, fig. 1. Now, comparing it to figs. 3 and 4 of the present Pl. V, the identity of nervation is defined by the five basilar veins, with a thin pair of marginal veinlets underneath; and by the upward direction of the internal lateral veins, which, in fig. 3 of Pl. VII, ascend to above the middle, pass still higher in the short oval leaf, Pl. V, fig. 3, and reach nearly to the obtuse point in fig. 4. The subdivision of the tertiary veins is in all the leaves of the same type, and the shape of the leaves or their outlines are mere modifications, depending upon the direction of the veins. The leaf, Pl. VI, fig. 4, is peltate from the point of attachment of the petiole near the middle. The character of the nervation remains, however, the same. It is somewhat obscured in the figure, from indistinctness of the specimen. But a larger, finer leaf of the same species, has been more recently procured by Mr. H. C. Towner, of Clay Center, Kansas, another of those proficient explorers whose researches have greatly increased the materials for the elucidation of the Cretaceous flora. This leaf, preserved in its whole is nearly round, with slightly undulate borders, and the nervation is marked by three pairs of primary veins, on each side of the mid rib, and under them by one pair of true marginal veinlets curving on each side toward the borders. Comparing, therefore, this peltate leaf with that of Pl. V, fig. 3, the position of the petiole is the only notable difference. The peltate form of these round leaves might perhaps suggest the fitness of some slight modification in the characters assigned to the genus *Pterospermites*, in the Cret. Flora, p. 94, the leaves being here rounded or subcordate at base. The difference is immaterial, and is remarked even upon leaves of the same species of *Menispermum* of our epoch. These round peltate leaves, for example, are so much like those of living species of *Cissampelos*, that they rather prove the adaptation of this generic division to all the Cretaceous leaves which I have referred to it.

The *Magnoliaceæ*, as order of the same class, are equally numerously and definitely represented in the North American Cretaceous flora in about the same proportion as they are in that of Europe. *Magnolia alternans* and *M. Capellini* have been described by Heer in his Phillites du Nebraska; and since, these two species have been recognized over

the whole explored area of the Dakota group, as also in the lower stage of the Cretaceous of New Jersey, and in the Upper Cretaceous of Greenland. Two other species have been described from the Dakota group: one, *M. obovata*, by Dr. Newberry, in his Ancient Floras; another, *M. tenuifolia*, in Cret. Flora. In Europe the leaves referable to this genus are of a different type than ours, larger and more beautiful. Two species—*M. amplifolia* and *M. speciosa*—are described by Heer in the Flora of Moletin, there represented by leaves and fruits. Count Saporta considers also as a Magnolia *Phyllites plagians*, Ung., of the flora of Gosau.

To the same order belong *Liriodendron*, so easily recognized in the peculiar form of its leaves. Its Cretaceous origin, or rather existence, is marked in the Dakota group by a number of specific representatives locally and distantly distributed. At least, though the first lot of Cretaceous specimens sent from Nebraska and Kansas for examination had many fragments of the species described in Cretaceous Flora, I have since received only a small leaf found in Kansas by Dr. Mudge, referable to *L. Meekii*. This genus is not as yet represented in the Cretaceous floras of Europe, nor in that of Greenland.

To the class of the *Columniferæ*, taking altogether the three orders, *Sterculiæ*, *Buttneriaceæ*, and *Pterospermæ*, are apparently referable the forms described under the generic name of *Protophyllum*, as well as the true *Credneria*. The *Sterculiaceæ* are more distinctly represented by a leaf described in this memoir as *Sterculia cretacea*. Though the nervation is obsolete, the mode of division of the leaf in equal linear diverging lobes is like that of species of this genus, which has also a well-defined species in both stages of the Cretaceous of New Jersey. To the *Tiliaceæ*, the leaves described as *Greviopsis Haydenii* have an evident affinity of characters.

The relation of Cretaceous species to the following and last classes of the vegetable reign is not very clearly defined. To the *Acereæ* is referable *Negundoides acutifolius* of the Cretaceous Flora. The leaf, however, as seen from the figure and description, is too fragmentary for a satisfactory determination of its characters. *Acer antiquum* is described by Ettinghausen in his Cretaceous Flora of Niedershœna. But even from the opinion of the author the reference is uncertain. The leaf rather resembles a deformed form of *Quercus* or of *Liriodendron*. Heer has from the Upper Cretaceous of Greenland a *Sapindus prodromus*, represented by one leaf only, which, however, has evidently the character of the genus. To the *Rhamni*, the leaf described as *Rhamnus tenax*, in Cretaceous Flora, is probably related, and this relation seems confirmed by the presence of *Celastrophyllum* and *Ilex* species in the same formation. Count Saporta, however, considers this leaf as showing more affinity of form and nervation to *Salix*. To the *Anacardiæ*, we have probably to refer as *Rhus debeyana*, that species described as *Populus* and as *Juglans*, as seen in Cretaceous Flora, p. 110. I have not obtained from the Dakota group any new materials comparable to this form, especially common in Nebraska. But I have seen a very fine specimen got out of a deep tunnel in Oregon, presenting upon its surface, with the details of nervation and areolation, some punctiform small protuberances, apparently oily glands, like those remarked upon leaves of the living *Rhus aromatica* and other species of this genus. A species of *Rhus* is described from the Cretaceous of Greenland by Heer, while considering historical authority, we have the same evidence in favor of *Juglans*, by a species of this genus in the Cretaceous flora of Moletin. Of the *Rosifloreæ*, we have from the Dakota group one leaf and

one fruit described as *Prunus*. I have recently received from M. Towner a fruit of the same character upon a specimen bearing leaves of *Aralia Towneri*. The *Myrtifloræ*, as well as the *Leguminosæ* present by a number of species in the Greenland Cretaceous, have not been till now positively recognized from Kansas and Nebraska specimens. The few groups not considered in this review have been remarked upon already in the Cretaceous Flora, and the former views, in regard to the leaves referred to them, have not been modified either by the remarks of European authors or by the discovery of new materials.

§ 2. DESCRIPTION AND ENUMERATION OF GENERIC AND SPECIFIC DIVISIONS.

With the descriptions of the new forms illustrated by the plates, this part of the memoir contains an enumeration of all the species established till now from the vegetable remains of the Dakota group, with remarks suggested by the examination of the materials discovered since the publication of the Cret. Flora*. In order to give to this enumeration the value of a synopsis of this flora, I have added to the specific names short descriptions, either copied in full or somewhat modified from those of the same volume.

For the discovery and the communication of the new materials, all collected in Kansas, the thanks of paleontologists are due especially to Messrs. Ch. Sternberg, of Fort Harker, H. C. Towner, of Clay Center, and also to Prof. B. F. Mudge, of Manhattan.

CRYPTOGAMOUS.

THALLOPHYTES.

ZONARITES DIGITATUS, Brgt., Cret. Flor., p. 44, Pl. I, fig. 1.

Frond flat, membranaceous, dichotomous, branching in an acute angle of divergence; divisions as broad or broader than the main axis, linear, entire, obtuse, slightly enlarging upward.

The reference of this species to that described by Brongiart from the Oolithe is contested especially by reason of difference in the geological station.

FILICES.

LYGODIUM TRICHOMANOIDES, Lesqx., Cret. Flor., p. 45, Pl. I, fig. 2.

Pinna linear, from the truncate base to the middle, enlarged and lobed upward by the forking of the middle nerve; veins broadly oblique, distinct, simple or forking from the base.

HYMENOPHYLLUM CRETACEUM, Lesqx., Cret. Flor., p. 45, Pl. I, figs. 3, 4.

Frond subcoriaceous, pinnæ linear oblong, pinnately divided into oblanceolate or cuneiform oblique pinnules, decurring to the convex, slightly winged rachis, more or less deeply bi-trilobate; lobes obtuse, simple-nerved.

This, like the former species and *Sphenopteris corrugata*, Newby., are contestable on account of the deficiency of the specimens.

PECOPTERIS NEBRASKANA, Heer. Cret. Flor., p. 46, Pl. XXIX, fig 5.

Pinnæ coriaceous, linear-lanceolate obtuse, alternately equally lobed; lobes more or less disjointed, turned outside, obtuse; middle vein thin, undulating; divisions alternate, ascending to the borders.

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* Report of the United States Geological Survey of the Territories, by Dr. F. V. Hayden, vol. vi, Cretaceous Flora (1874).

GLEICHENIA KURRIANA, Heer., Cret. Flor., p. 47, Pl. I, Figs 5–5c.

Frond pinnate; pinnæ long, linear, pinnately equally lobed; lobes nearly at right angle to the rachis separated to near the base; medial nerve thick, pinnately branchiug, veins forking at the middle.

GLEICHENIA NORDENSKIOLDI, Heer, Flor. Foss. Arct., p. 50, Tab. IX, figs. 6–12.—Pl. II, fig. 5.

Frond slender dichotomous, bi-polypinnate; ultimate pinnæ alternate, rigid, open, linear, parallel; leaflets free, oblong obtuse, rounded at their base, inclined upward, coriaceous; secondary veins few, three or four pairs, the lower forking, the upper simple.

This species is very distinct from the former, and the differences in the characters easily seen even in our fragmentary specimens. In the one figured here, the pinnules are separated to their base, and not mere lobes as in the former; they are turned upward, and by the upper basilar border they compress the rachis, which becomes evidently flexuous, in our specimen, at least; the veins, also, are more distant, or less divided. The fructifications of this fine fern are marked upon the specimens of Greenland by two large round sori on each side of the middle nerve, near the base of the leaflets. There is no difference whatever in any of the characters of the Kansas specimen with those of the Greenland form. Even the undulation of the primary rachis distinctly remarked in Tab. IX, fig. 7, of Heer's flora, is equally distinct in the primary rachis of the fragment figured here. This species has been observed on specimens from the Lower Cretaceous of Greenland only, wherefrom Professor Heer has described thirteen species of *Gleichenia*, while only two were found in the specimens of the Upper Cretaceous of the same country.

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

PHÆNOGAMOUS.

CYCADEÆ.

PTEROPHYLLUM (?) HAYDENII, Lesqx., Cret. Flor., p. 49, Pl. I, fig. 6, 6c.

Frond linear, simply pinnate; rachis rugose, half an inch broad or more, marked by circular dots in vertical rows, and regularly placed about half a centimeter distant, apparently scars of the points of attachment of the pinnæ; pinnæ (or leaves) entire, oblong, oval-obtuse, slightly arched on the lower side, flat, attenuated at the round point of connection to the rachis, regularly and narrowly striated lengthwise.

Of this peculiar organism, no other part has been discovered except the fragment figured. Professor Heer regards it as unreferable to the *Cycadeæ*, on account of extraordinary broad stem, and supposes that it should rather be considered as a Conifer, of the section of the *Araucarites*. This opinion seems confirmed by the presence upon the same specimens of the cone described here below as *Abietites Ernestinæ*, both cone and branch being originally described as representing a same species related to *Pterophyllum Ernestinæ* of Stiehler, described from similar fragments in the Paleontographica.

CONIFERS.

ABIETITES ERNESTINÆ, Lesqx., Cret. Flor., Pl. I, fig. 7.

Cone oblong, abruptly narrowed to a short pedicel, scales broad, truncate, appressed and imbricated.

SEQUOIA FORMOSA, Lesqx., Cret. Flor., p. 50, Pl. I, figs. 9 and 9ᵃ.

Cone spindle-shaped, tapering upward from above the base and more rapidly narrowed to a short petiole; scales closely appressed and imbricated, rhomboidal, margined.

SEQUOIA REICHENBACHI ?, Heer, Cret. Flor., p. 51, Pl. I, figs. 10, 10ᵇ.

Cone small, oblong, oval; receptacles oval, pointed at both ends; foliaceous scales crumpled, deeply embedded into the stone; seeds small, oval-oblong.

In comparing this cone to the figures given of the species by Professor Heer in his Moletin flora, the reference was made especially to fig. 3 of Pl. I. Professor Heer remarks rightly that there is no relation between these cones of Moletin and the one of Nebraska, the former being much larger and the scales therefore longer, and that though representing apparently a species of Sequoia, the specific name should be left undetermined until better specimens have been discovered.

SEQUOIA FASTIGIATA ? Sternb., Heer, Mol. Flor. p. 11, Pl. I, figs. 10, 13.—Pl. III, figs. 2 and 8.

Branches erect, slender; branchlets filiform, fastigiate, crowded; leaves loosely imbricated, short, decurrent at the base, broadly lanceolate, acuminate, subfalcate, or more or less curved upward; nerved.

We know of this species only what is seen in the small branch figured 8 and 8ᶜ, for the cones of the same plate, fig. 2, though observed upon specimens of the same locality, have not been found in connection with the branches bearing leaves. The leaves appear of the same form and characters as those represented by Heer in his Moletin Flora, *loc. cit.*, and as those from the Greenland Upper Cretaceous flora by the same author, p. 102, Pl. XXVII, figs. 5 and 6, merely differing by the presence of a middle nerve recognizable upon the specimens of Kansas, and which is not seen upon the leaves of Greenland and Europe. This mode of division of the branches is the same, and in comparing the cones of our fig. 2 with those figured by Heer from both Greenland and Moletin specimens, the likeness appears very great indeed. As the leaves of this species are very variable in size and the middle nerve generally perceivable with great difficulty, I am not disposed to separate it from the only difference of the more distinct middle nerve of the leaves, and I consider it as very probably the same as that of Moletin. Heer remarks a character also recognizable upon the fragment from Kansas, viz, the difference of the size of the leaves upon different parts of the branches.

HABITAT.—Kansas, Clay Center, *H. C. Towner.*

SEQUOIA CONDITA, sp. nov., Pl. IV, figs. 5–7.

Branches rigid, pinnately divided; branchlets slender, filiform, open or oblique; leaves either short, oblong pointed narrowed to the decurring base, appressed to the stem, or longer, subulate acuminate, open and slightly falcate, nerveless; cone small, oval-oblong, scales rhomboidal, acutely mammillate.

After briefly describing this species for the Bulletin No. 5, second series of the Geological Survey of the Territories, I received from Clay Center a number of fragmentary specimens satisfactorily showing its various characters. They prove that the fragment, Pl. IV, fig. 7, which I had considered as representing a different species, and described as doubtfully referable to *Sequoia subulata*, Heer, of the Greenland Cretaceous flora, belongs to the same species as the fragment, fig. 5.

In this one, the leaves closely appressed to the stem, either imbricated or distant, two millimeters long, one millimeter broad in the broadest part above the middle, have an oblong, elongated rhomboidal form, with a short, acute point, and gradually taper from above the middle to the decurrent base. In other specimens they are, as in fig. 7, linear, acuminate, or subulate, four to five millimeters long, less than one millimeter broad, decurring at the base, more generally half open and straight, sometimes, however, slightly falcate. Passing downward upon the same branches, these leaves become shorter, more closely appressed to the stem, the point only being turned outside, and they then are similar to those of the enlarged fig. 5, differing merely by the size. A number of fragments of cones, also, one of them preserved nearly whole, and still attached to a branch, prove that fig. 6 represents rather an unopened young fruiting catkin of the same species than a male one, as I supposed at first. The ripe cone is fourteen millimeters long, five millimeters broad, cylindrical-oval, with scales deeply impressed into the stone, and the apophyses three to four millimeters broad and nearly as long, rhomboidal in outline, acutely narrowed on both sides, bearing in the middle or a little above a pointed (?) mammilla, marked by a small hole in the stone. Another cone, cut in its length exposes the thick, smooth (not crumpled) foliaceous appendages, and the receptacles of the seeds, which are large and similar to those of the cone described in Cret. Flora, Tab. I, Fig. 10 and 10[b], as *Sequoia reichenbachi*. Indeed, the form of the opened cone is the same; this last one appears only somewhat longer. All the fragments representing this species are, like the cones, deeply impressed or molded into the stone, even the leaves, which often penetrate it by their points. They appear thus of a thick coriaceous consistence. Their outside surface is, of course, the only part whose impression is represented. It is half-round or slightly channeled; the inside surface, if exposed, could perhaps show a middle nerve. This species is distantly related to *Sequoia fastigiata*, Sternb., described above, differing by the pinnate mode of division of the branches, the form of the leaves, etc. The fragment, fig. 7, has a likeness to the one represented by Heer in his Flor. Foss. Arct. III, Pl. XXVII, fig. 9[c], as *Sequoia rigida*, a species, however, far different by the visible nerve of its leaves and by the large size of its cones.

HABITAT.—Fort Harker and Clay Center, *Chs. Sternberg*, *H. C. Towner*.

PINUS QUENSTEDTI, Heer, Moletin Flora, p. 13, Pl. II, figs. 5–9, and Tab. III.—Pl. III, figs. 6, 7.

Leaves by five, very long and slender, linear, deeply nerved, the base inclosed in a long cylindrical sheath; cones cylindrical, very long, scales with a broadly rhomboidal shield (apophyse) acute on the sides, mammillate in the center.

The specimens representing this species are numerous, but all more or less fragmentary. The attachment of the base of the leaves by five is more or less distinctly marked by the long sheaths forming deep holes into the stone, the orifice of which has remains of leaves; these are very numerous, always seen by their deep impressions, half cylindrical on the back, channeled and deeply nerved on the inside, as marked in the enlarged figure 7[a]. The length of these leaves is not recognizable from our specimens, which have mere fragments, five to eight centimeters long; but Prof. Heer, who had complete splendid specimens for his description, gives the measure at twenty centimeters; their width being scarcely one millimeter. The cylindrical cone is

twenty-two millimeters broad, gradually tapering to the base, and from what is seen from large stones perforated by its impressions, its length was at least fifteen centimeters. Most of the specimens whereupon it is represented show it curved or paltate. It is the only difference remarked in comparing it to the cones, represented by Heer, from the Moletin flora, and which are straight. In the flora of Gelinden, by Saporta and Marion, the authors remark, p. 19, that this species does not differ in any character from the living Mexican species, with quinate leaves, which now compose the section of the *Pseudo-strobus*.

HABITAT.—Mostly and more generally found near Fort Harker, by *Chs. Sternberg*; some leaves are mixed with the specimen of the former species sent by *H. C. Towner* from near Clay Center.

GLYPTOSTROBUS GRACILLIMUS, Lesqx., Cret. Flor. p. 52, Pl. I, figs. 8, 11–11f.

Branches fastigiate, very slender, thread-like, much divided; leaves imbricate, appressed, embracing the base, linear-lanceolate, more or less abruptly pointed; cone narrow, cylindrical.

No new specimens of this remarkably fine species of Conifers has been found; its reference is therefore still uncertain. I consider it, from the affinity of its characters to those of *Frenelites reichii* of Ettinghausen, as identical with this species. But its true relation, even if identity was positive, is not the better ascertained for that. Schimper admits* this Frenelites as a synonym of *Sequoia fastigiata*, Sternb. The presence of both these species in the Cretaceous of Kansas would perhaps give to this opinion a kind of authority. But it seems contradicted by the great difference in the appreciable characters of these remains as far as they are known. We can, however, say nothing in regard to the affinity of this *Glyptostrobus* or *Frenelites*, as long as its cones are unknown. If the scales found in connection with the branchlets and figured in Cret. Flor. Pl. I, fig. 8 (enlarged), belong to it, they rather resemble those of the cones of *Sequoia condita*, which, however, are longer, narrower, and of a different type than those of *S. fastigiata*.

INOLEPIS? species. Pl. IV, fig. 8.

Cone or fruit globular, five-costate, attached to a branch mixed with undeterminable remains of conifers.

The specimen is distinctly represented in the figure; it shows the deep semi-globular impression of an apparently unopened fruit, marked in the length by five obtuse costæ or narrow ribs coming together, and disappearing below the top. The other fragments attached to the stem above this impression appear like the scales of an opened cone or fruit of the same species. I find nothing to which this can be compared but the cross-section of a cone of *Inolepis imbricata*, Heer., Flor. Foss. Arct., Pl. VXI, fig. 16, supposing that the impression of our specimen represents the outside surface of a cone of this kind deprived of its scales. This affinity is indeed a distant one, and the comparison is acceptable merely on account of the connection of this vegetable organism with a mass of decayed and broken remains of Conifers.

PHYLLOCLADUS SUBINTEGRIFOLIUS, Lesqx., Cret. Flor., p. 54, Pl. I, fig. 12.—Tab. II, fig. 4.

Leaf coriaceous, oval-oblong, tapering from below the middle to a short thick petiole; undulate toward the top and abruptly rounded; middle nerve

* Paleontologie Vegetable, vol. ii, p. 316.

narrow and scarcely distinct except near the base where it becomes inflated; lateral veins close and thin, a few of them more prominent and thicker, all running to the borders in an acute angle of divergence and nearly straight.

The fragment figured here is the second specimen of a leaf of this kind observed in the Cretaceous. Its relation seems authorized.

MONOCOTYLEDONUS.

GLUMACEÆ.

PHRAGMITES CRETACEOUS, Lesqx., Cret. Fl., p. 55, Pl. I, figs. 13 and 14; Pl. XXIX, fig. 7.

Leaves and culms of various size, the leaves gradually narrowed to an obtuse point, doubly veined; primary veins thickish or inflated by the epidermis, under which only the intermediate secondary veins, three or four, may be discernable.

The reference of the fragment of stem and the knot, Pl. I, figs. 13 and 14, and of the leaf, Pl. XXIX, fig. 7, of the Cret. Flor., has been contested as very uncertain. The exactness of the determination, however, is rendered probable, at least, by the presence of fragments of the same kind in the Upper Cretaceous of Greenland, and described by Heer, *loc. cit.*, p. 104, Pl. XXVIII, figs. 8, 11, as *Arundo grœnlandica*. The leaf, fig. 11, and its point, fig. 11[b], have the same form as that of our fig. 7. I have more recently still received a number of fragments of small culms, one to one and a half centimeters, representing still more clearly the characters of the species. The distance between the primary veins is variable.

DIOSCOREÆ.

DIOSCOREA? CRETACEA, Lesqx., Cret. Flor., p. 56, Pl. XXVIII, fig. 10.

Leaf coriaceous, entire, nearly round, slightly emarginate at the point, broader than long, rounded or truncate at the base; veins apparently all from near the base, the outside ones curving parallel to the borders and sparingly branching; the other parallel to each others, simple, curving in the same way in ascending, connected in the upper part by arched nervilles, the inner ones acrodrome.

PALMÆ.

FLABELLARIA? MINIMA, Lesqx., Cret. Flor., p. 56, Pl. XXX, fig. 12.

Rays narrow, splitting in laciniæ; veins prominent, parallel; intermediate space concave, marked by indistinct veinlets parallel to the primary veins.

The reference of these small fragments to the Palm family is generally contested.

DICOTYLEDONOUS. APETALEÆ.

ITEOIDEÆ.

LIQUIDAMBAR INTEGRIFOLIUM, Lesqx., Cret. Flor., p. 56, Pl. II, figs. 1–3; Pl. XXIV, fig. 2.

Leaves coriaceous, variable in size, deeply five-palmately lobed; divisions ovate lanceolate, obtusely pointed, entire, separated by obtuse sinuses; inferior lateral lobes in right angle to the midrib; nervation camptodrome.

POPULITES LANCASTRIENSIS, Lesqx., Cret. Flor., p. 58, Pl. III, fig. 1.

Leaf large, coriaceous, broadly cordate, apparently pointed, entire or with slightly undulate borders; nervation pinnate, subcamptodrome.

According to Schimper, this species is a true Populus.

POPULITES ELEGANS, Lesqx., Cret. Flor., p. 59, Pl. III, fig. 3.

Leaves broadly oval or nearly round, narrowed by an abrupt curve to a long, slender petiole; borders entire, undulate; nervation pinnate, subcamptodrome, the lower primary veins joining the middle nerve a little above the border-base of the leaf.

SALIX PROTEÆFOLIA, Lesqx., Cret. Flor. p. 60, Pl. V, figs. 1–4.

Leaves lanceolate, gradually tapering to an obtuse point, largest at or more generally below the middle, narrowed to a short petiole; coriaceous, surface polished.

AMENTACEÆ.

BETULA BEATRICIANA, Lesqx., Cret. Flor., p. 61, Pl. V, fig. 5; Pl. XXX, fig. 4.

Leaves small, rhomboidal-obovate in outline, cuneiform from the middle to the petiole, rapidly tapering from above the middle to a point, simply dentate in the upper part, entire to the base; nervation pinnate, craspedodrome.

In his critical notes, Count Saporta says that these leaves might be, perhaps, detached leaflets of some species of *Cissus* or *Araliopsis*, the presence of Betula leaves being improbable in the Cretaceous.

MYRICA OBTUSA, Lesqx., Cret. Flora, p. 63, Pl. XXIX, fig. 10.

Leaf thick, coriaceous, shining, linear, obtuse, entire; medial nerve thick; secondary veins thin, nearly at a right angle to the middle nerve, curving near and along the border in marginal festoons, anastomosing, from the middle or above, with the branches of intermediate short veinlets.

MYRICA CRETACEA, sp. nov. Pl. III, fig. 4.

Leaf linear lanceolate long (point broken), gradually narrowed to a thick petiole; minutely denticulate on the borders, secondary veins parallel, distant, at an acute angle of divergence from the flat broad middle nerve, camptodrome; tertiary veins short, anastomosing with branches of the secondary ones.

The figure shows the only fragment known of this species. The substance of the leaves is subcoriaceous, rather thick, the surface smooth or polished; the borders, slightly reflexed, minutely denticulate, evidently so, but not quite as deeply as marked upon the figure; from the broad middle nerve, the secondary veins, irregular in distance and branching, ascend, in an acute angle of divergence, about 30° to near the borders, which they closely follow by ramifications. The areolation is not distinguishable.

The leaf is comparable to *Myrica* (*Dryandroides*) *Zenkeri*, Ett., Kreide Flora von Neidershoena, p. 23, Pl. III, figs. 1, 3, 11, which is also published by Heer from Greenland, in the Arct. Flora. Though our leaf is larger and the denticulation of the borders of a different character, in right angle to the borders not as pointed and turned upward as in the European species, these differences might be merely local and the species identical. A close comparison is not possible, from the absence of the characters of the secondary nervation, on the specimens of Europe and of Greenland. Ettinghausen, however, remarks that the teeth of the borders are minute and acute, *or slightly obtuse and close*, as

in our leaf, but adds that the secondary veins are very slender (*tenuissimi*), while in ours they are thick and distinct.

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

MYRICÆ SEMINA, Cret. Flora, p. 63, Pl. XXVII, figs. 4 & 4ª.

Seeds obovate, a little more than two millimeters in the upper part, pointed at the other side, bordered by a narrow margin.

CUPULIVIERÆ.

DRYOPHYLLUM (QUERCUS) LATIFOLIUM, spec. nov. Pl. VI, fig. 1.

Leaf large, oval, obtuse at the top and base, sinuate or obtusely dentate; lateral veins on an acute angle of divergence, straight to the borders, branching once or twice.

This fine leaf is coriaceous, twelve centimeters long, nine centimeters wide below the middle, its broadest part, obtuse at the point and base, deeply undulate, or, rather, obtusely dentate at least in its upper part. The nervation is thick, the secondary veins pass up at an angle of divergence of 50° to the borders, and enter the teeth, while the upper division or veinlets pass under the sinuses and follow the borders, a marked character of the species of this section; the nervilles are distinct though thin, in right angle to the secondary veins, distant and disconnected; the ultimate areolation is obsolete. The leaf resembles somewhat by its form *Quercus Olafseni*, Heer, of the Flora Arctica.

HABITAT.—Fort Harker, Kansas, *Chs. Sternberg.*

DRYOPHYLLUM (QUERCUS) PRIMORDIALE, Lesqx., Cret. Flora, p. 64, Pl. V, fig. 7.

Leaf subcoriaceous, narrowly ovate-lanceolate, equally gradually tapering from the middle upward to a point and downward to a short petiole, sharply equally dentate; nervation pinnate, simple, craspedodrome.

DRYOPHYLLUM (QUERCUS) SALICIFOLIUM, sp. nov., Pl. VIII, fig. 2.

Leaf linear lanceolate, rounded to the base; borders acutely denticulate, with small teeth turned outward in the lower part, upward in the upper part, lateral veins numerous, parallel, subcamptodrome.

The fragment represents a slightly falcate leaf, rather membranaceous than coriaceous, with a narrow middle nerve and close parallel secondary veins, most of them ascending to the teeth and passing under the sinuses by an upper branch, or some of them curving along the border and reaching the teeth by a small division. The areolation is not distinct; only in the upper part of the leaf the nervilles, in right angle to the veins, appear ramified in the same way, ending in square or polygonal areolæ.

This species is comparable, and, indeed, closely related to *Dryophyllum lineare*, Sap., Sezane flora, p. 350, Pl. IV, fig. 6.

HABITAT.—Near the San Juan River, at a higher Cretaceous station than the Dakota group, Southwest Colorado, *W. H. Holmes.*

QUERCUS HEXAGONA, Lesqx., Cret. Flor., p. 64, Pl. V, fig. 8.

Leaf rhomboidal ovate, tapering from above the middle to an acute point, narrowed, wedge-form to the petiole, irregularly broadly dentate in the upper part only, nervation pinnate, simple craspedodrome.

QUERCUS? ELLSWORTHIANA. Lesqx., Cret. Flor., p. 65, Pl. VI, fig. 7.

Leaf subcoriaceous, oblong oval, point broken, narrowed in a curve to the base; borders undulate; nervation pinnate, camptodrome.

The relation of this fragment is as yet uncertain.

QUERCUS? PORANOIDES, Lesqx., Cret. Flora, p. 66, Pl. XXX, fig. 9.

Leaf broadly oval or nearly round, point broken, truncate at the base, undulate on the borders, middle nerve thick, lateral veins thin, subopposite, at an open angle of divergence, curving to and along the borders, camptodrome. The reference of this fragment is as uncertain as that of the former.

FAGUS POLYCLADA, Lesqx., Cret. Flor., p. 67, Pl. V, fig. 6.

Leaf ovate, oblong, cuneate to the base, short petioled; borders entire, undulate; middle nerve straight, secondary veins close, numerous, simple, parallel and craspedodrome.

PLATANEÆ.

PLATANUS OBTUSI LOBA, Lerqx., Cret. Flor., p. 69, Pl. VII, figs. 3, 4.

Leaves small, not thick, palmately irregularly trilobate; lobes obtuse, short with regularly undulate borders, nervation 3 to 5 palmate from a distance above the base of the long petioled leaf.

PLATANUS PRIMÆRA, Lesqx., Cret. Flora, p. 69, Pl. VII, fig. 2, and Pl. XXVI, fig. 2.

Leaves large, coriaceous, palmately trilobate, with short, scarcely distinct lateral lobes, broadly deltoid, deeply, distantly dentate to the point; nervation three palmate, coarse, platanoidal.

PLATANUS HEERII, Lesqx., Cret. Flora, p. 70, Pl. VIII, fig. 4, and Pl. IX, figs. 1 and 2.

Leaves round or broadly rhomboidal in outline, palmately three obscurely lobed; lobes short, obtuse; borders entire or undulate broadly wedge-form at base and more or less decurrent to the short petiole.

We have of this fine species a specimen representing a small leaf nearly entire on the border and with the trilobate form scarcely defined. The supposition that these leaves could be referable to *Credneria* is contradicted by the short petiole, besides the other differences indicated in the introduction.

PLATANUS NEWBERRIANA, Heer, Cret. Flora, p. 72, Pl. VIII, figs. 2, 3; Pl. IX, fig. 3.

Leaves of medium size, thickish, palmately three-lobed, either tapering to a point from the lateral lobes upward, or without lobes and ovate; taper-pointed, broadly cuneate to the base, equally dentate; nervation trifid from a little above the base; secondary veins close, numerous.

PLATANUS DIMINUTIVA, Lesqx., Cret. Flora, p. 73, Pl. VIII, fig. 5.

Leaf small, thick, half round from the middle to the base, narrowed to an obtuse point; borders entire, undulate; nervation trifid from above the base; nerves thick and irregularly inflated.

As remarked already, this may be a diseased leaf of one of the former species.

URTICINEÆ. MOREÆ.

FICUS HALLIANA, Lesqx., Cret. Flora, p. 68, Pl. XXVIII, figs. 3 and 9.

Leaves subcoriaceous, very entire petioled, broadly lanceolate, gradually narrowed to a long acumen, more rapidly narrowed and rounded to the petiole, nervation pinnate; lateral veins close, straight on an acute angle of divergence, parallel, numerous.

FICUS LAUROPHYLLUM, sp. nov. Pl. V, fig. 7.

Laurophyllum reticulatum, Lesqx., Cret. Flora, p. 76, Pl. XV, figs. 4, 5.

Leaves coriaceous, entire narrowly lanceolate acuminate, gradually tapering to a short, thick petiole; nervation pinnate, middle nerve thick, grooved, secondary veins close, open.

A large number of specimens have been obtained of this fine species. Though generally more or less fragmentary, they indicate, by comparison, the essential characters of the leaves. They vary in size from one and one-half to four and one-half centimeters broad in the middle, and from ten to eighteen centimeters long. Their form is like that of Pl. V, fig, 7, of this memoir, which is an exact likeness of the only leaf seen preserved in its whole. The secondary veins are always open, nearly at a right angle to the very thick, broad, and grooved or rather channeled middle nerve. The areolation is by fibrillæ at right angle to the secondary and intermediate tertiary veins, forming irregular quadrate or polygonal loose meshes. The secondary veins curve along the borders, and, connecting with those above, form a kind of margin, very undistinct, however, to the leaves. These characters of nervation and areolation more evidently refer this species to the *Ficus* than to any division of the *Laurineæ*. They are the same as in the leaves described as *Ficus protogcæ*, Heer, in Flora Arct. III, p. 108, Pl. XXX, figs. 1–8 of the Upper Cretaceous of Greenland. Some living species, especially of Cuba, have the same type of nervation and areolation. The relation of these leaves is also marked to species of *Nerium*.

FICUS DISTORTA, sp. nov., Pl. V, fig. 5.

Leaf coriaceous, entire, obovate, unequilateral, pointed or acuminate, apparently gradually narrowed to the base (broken); nervation pinnate, secondary veins thick, parallel, equidistant camptodrome; nervilles in right angle to the veins, areolation irregularly quadrate or polygonal.

This fragment as figured here is the only one seen of this species, and it is not sufficient to positively indicate the relation of the species to *Ficus*; the unequilateral shape of the leaf, its nervation and areolation seem to authorize its reference to this genus.

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

LAURINEÆ.

Laurus Nebrascensis, Lesqx., Cret. Flora, p. 74, Pl. X, fig. 1, Pl. XXVIII, fig. 14.

Leaves thick, coriaceous, elliptical oblong or narrowly lanceolate, obtusely pointed, tapering downward to a short, thick petiole; middle nerve thick, half round; secondary veins alternate, at an acute angle of divergence, camptodrome.

LAURUS MACROCARPA, Lesqx., Cret. Flora, p. 74, Pl. X, fig. 2.

Fruit round, oval; nut surrounded by a thick pericarp; pedicel club-shaped.

The fruit may belong to the species represented by the leaves of *Laurus Nebrascensis.*

LAURUS PROTEÆFOLIA, sp. nov., Pl. V, figs. 1 and 2.

Leaves subcoriaceous, broadly lanceolate, gradually narrowed from below the middle into a long acumen, more rapidly narrowed to the base; middle nerve narrowly grooved and comparatively narrow; lateral veins oblique, slender, curving to and along the borders, parallel, except the lower pair, which is more oblique and ascends higher.

These leaves, of which we have a number of specimens, the two best ones figured here, vary in size from two to three and one-half centimeters broad in the widest part, far below the middle, and twelve to sixteen centimeters long. By their shape, the long narrowly tapering and slightly falcate acumen, they closely resemble *Proteoides daphnogenoides*, Heer, as represented in Cret. Flora, Pl. XV, figs. 1 and 2, differing, however, by the broader middle nerve and the distinct, equidistant and parallel secondary veins. These, at an acute angle of divergence of about thirty degrees, are somewhat curved in passing toward the borders, where they become effaced; the lower pair is at a more acute angle of divergence and ascends higher in following the borders; the areolation is obsolete, the surface appearing punctulate or closely dotted by small convex areolæ, like the leaves of some species *Laurus* or *Persea*.

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg*.

PERSEA LECONTEANA, Lesqx., Cret. Flora, p. 75, Pl. XXVIII, fig. 1.

Leaf large, oblong-ovate, lanceolate pointed; borders undulate, nervation pinnate; lower secondary veins distant, at a more acute angle of divergence, curving near the borders and ascending to the middle of the leaves; upper veins shorter, parallel.

The character of the nervation is the same as in the former species. The relation of this leaf is, however, contested, on account of its size and shape, which seem more like those of a *Magnolia*.

PERSEA STERNBERGII Lesqx., Cret. Flora, p. 76, Pl. VII, fig. 1.

Leaf large, thick, coriaceous, entire, broadly oblong, oval, or obovate, obtusely pointed? (point broken), gradually narrowed in a curve to the base; nervation pinnate, very distinct, camptodrome.

DAPHNOGENE CRETACEA, sp. nov.

Cinnamomum Scheuchzeri, Heer, Cret. Flora, Pl. XXX, figs. 2, 3.

Leaves coriaceous, polished on the upper surface, elliptical or ovate-lanceolate, pointed, narrowed to a short petiole; slightly undulate on the borders, and triple-nerved from a distance above the base; middle nerve and lateral veins thick, the lower primary ones ascending along the borders as high as the lower secondary veins, which they join by ramifications.

To Professor Heer, the reference of these leaves to *Cinnamomum Schenchzeri* seems very hazarded, for though the form of the leaves is much the same, the middle nerve is too thick for that species, especially toward the point. Count Saporta is also of the opinion that the presence of *C. Scheuchzeri* in the Cretaceous is very improbable, as this species in Europe is essentially of the Upper Miocene. I have accordingly changed the name of this species, which, though positively referable to the *Laurineæ*, is as yet uncertain in its relation. The genus *Daphnogene*, Ung., less definitely limited, is appropriate for leaves of this kind, to which the following species is also referred. These two leaves are distantly related to *Cinnamomum Mississippiense* of the lignitic.

DAPHNOGENE HEERII.

Cinnamomum Heerii, Lesqx., Cret. Flora, p. 84, Pl. XXVIII, fig. 11.

Leaf thickish, subcoriaceous, entire, ovate, taper-pointed, rounded at the base, three-nerved; lateral veins ascending higher than the middle of the leaf, branching outside.

OREODAPHNE CRETACEA, Lesqx., Cret. Flora, p. 84, Pl. XXX, fig. 5.

Leaf coriaceous, elliptical, gradually curving to an obtuse point, narrowed in about the same degree to the base; middle nerve thick, secondary veins thick and opposite, three or four pairs, inflated at the axils.

SASSAFRAS.

The remarks in the introduction expose the opinions of paleontologists and the discussion upon the species referred to this generic division from the specimens of the Dakota group. They prove that, though the number of these leaves is very large, their generic reference is still very uncertain. Leaving aside for the present the task of deciding on the evidence in regard to the degree of their relation to Sassafras or Aralia, I shall here describe them provisionally under the generic name of *Sassafras* and *Sassafras* (*Araliopsis*), placing this group altogether at the end of the *Laurineæ* until we get some more positive information on the subject.

SASSAFRAS MUDGEI, Lesqx., Cret. Flora, p. 78, Pl. XIV, figs. 3, 4; Pl. XXX, fig. 7.

Leaves proportionally long; primary nerves narrow, at an acute angle of divergence; middle lobe twice as long as the lateral one; all ovate-lanceolate obtusely pointed; base of the leaves narrowed, acutely cuneate to the petiole; surface of the leaves polished.

SASSAFRAS ACUTILOBUM, Lesqx., Cret. Flora, p. 79, Pl. XIV, figs. 1, 2.

Leaves subcoriaceous, of the same consistence as the former species; lateral lobes lanceolate, sharply pointed, entire, middle lobe twice as long as the lateral ones, which diverge nearly at right angle; base of the leaves narrow and tapering.

The leaves of this and the former division are rare among the specimens furnished to me. This so-called species is perhaps a variety of the former. Both were found at the same locality.

SASSAFRAS (ARALIOPSIS) CRETACEUM, Newby., Cret. Flora, p. 80, Pl. XII, fig. 2.

Leaves comparatively of small size, with diverging, obtusely pointed, short lobes, enlarged toward the broad sinuses; broadly cuneiform, and decurring to the rachis, long petioled; border entire.

VAR. DENTATUM, Cret. Flora, Pl. XI, figs. 1, 2.

Differs by the lobes more or less dentate on the borders, and the secondary veins subcamptodrome or mixed.

SASSAFRAS (ARALIOPSIS) CRETACEUM OBTUSUM, Lesqx., Cret. Flora, p. 80, Pl. XII, fig. 3, Pl. XIII, fig. 1.

Leaves of various size, some of them very large, with short obtuse entire lobes, the lateral diverging in an obtuse angle and the nervation coarse and very deep.

From a number of specimens examined, this form appears truly distinct by its peculiarly broad nervation. Even in the smallest leaves the primary nerves are twice as thick as in the leaves described as Sassafras cretaceum. This character is well marked upon fig. 3 of Pl. XII especially. It cannot be considered as a modification resulting from the different face of the leaves preserved by the specimens, as some of these in the collection are double specimens, representing both faces, where the same difference is distinctly remarked. I have also not seen any leaves of this coarse nervation with dental borders; the lobes are always entire. To this division are referable some leaves evidently of the same type, but entire, or not lobed. One of them has been described in Cretaceous Flora as *Sassafras? subintegrifolium*, p. 82, Pl. III, fig. 5, which is apparently abnormal or distorted by compression. A number of better specimens represent leaves of this kind nearly entire or broadly oval, with one obscure lobe on one side, or none, and the deep, coarse, broad nerva-

tion which is a character of this so-called variety. I will further remark that specimens of both the entire and trilobate leaves were found at the same locality.

SASSAFRAS (ARALIOPSIS) MIRABILE, Lesqx., p. 80, Pl. XII, fig. 1.

Leaves thick, coriaceous, large; lobes broad and short, the lateral ones on a broad angle of divergence, with borders dentate or deeply, undulately lobed; secondary veins mostly craspedodrome.

A remarkable modification of the character of this species is observed upon a fine leaf still much larger than the one figured in the Cretaceous Flora. It is twenty centimeters broad between the points of the lower lateral lobes; about fifteen centimeters long from the top of the petiole (lower part of the leaf destroyed), divided by the forking of the lateral primary veins in five equal and equally sinuate dentate lobes, with the same character of nervation as in the normal form. The lobes also are of equal length and width; the middle one fifty-seven millimeters broad and scarcely sixty millimeters long, with the lower secondary veins camptodrome and the upper ones craspedodrome, and entering the teeth. As I have remarked it already, this subdivision in four lobes tends to show the reference of those large leaves to *Aralia* rather than to *Sassafras*. But it may be also an exposition of that disposition to polymorphy so remarkably evident in the leaves of our living *Sassafras officinale*. As these generally tripalmate leaves pass to an entire oval shape sometimes, they subdivide more or less in the same way. One of the largest specimens of *S. mirabile*, lately received from Mr. Towner, of Clay Center, Kansas, has one of the lateral primary nerves twice as thick as the other, and its base is higher. One of its lobes is, therefore, much longer, fifteen and one-half centimeters, while the other is only ten.

SASSAFRAS, (ARALIOPSIS,) RECURVATA.

PLATANUS RECURVATA, Lesqx., Cret. Flora, p. 71, Pl. X, figs. 3–5.

Leaves three to five palmately lobed; lobes nearly equal in length, the middle one broader, lateral nerves curving downward, simple or forking above the base; borders of the lobes entire or sparingly coarsely dentate.

This form is still more uncertain, and, so to say, transient in its characters. By the decurrent base of the leaves descending to the petiole, lower than the point of union of the primary veins and also by the trilobate division, it is a *Sassafras*. The irregularity, however, of the lobes, the nervation and the double divisions in lobes or teeth refer it to *Platanus*; the tendency to become five-lobate by the forking of the lateral nerves is a character of the *Araliaceæ*. This disposition to a subdivision or multiplication of lobes is seen in fig. 3, where the lower branches, though thick, do not diverge widely enough for modifying the borders of the leaf, but are curved inward and join the secondary veins at the base of the lobes; but in fig. 4, which represents a fragment only, the subdivision in five lobes is evident. It is still more marked upon a leaf recently found and figured by Mr. H. C. Towner. In this one the cuneate base of the leaf descends far down, two and one-half centimeters lower than the point of union of the primary nerve; the lateral ones divide in two branches from below the middle, and curving backward they form well-defined ovate pointed short lobes, and thus a palmately five-lobed leaf of the *Aralia* type. This leaf, without the petiole, which is broken, is twelve centimeters long, and as wide between the points of the lowest lateral lobes, which are only one and one-half centimeters long; the others, as also the middle one, are three centimeters long and about as wide, being half round, cuspidate, and separated by narrow obtuse sinuses.

PROTEACEÆ.

LOMATIA? SAPORTANEA.

TODEA? SAPORTANEA, Lesqx., Cret. Flora, p. 48, Pl. XXIX, figs. 1-4; Pl. VI, fig. 2 (enlarged).

Leaves coriaceous, pinnately laciniate; divisions entire, narrowly lanceolate, pointed, connected by the decurring base, which forms a more or less broad and nerved wing to the rachis; primary veins thick, ascending to the point; secondary veins distinct, at an acute angle of divergence, close, parallel, curving up in passing to the borders and following them in simple festoons; areolation mixed by tertiary veinlets and their branches in various angles of divergence.

The fine specimens figured in the Cret. Flora, as quoted above, represent the essential characters of the leaves; the branches parallel and distichous? along the primary stems, a disposition similar to that of the fronds of a number of species of large ferns by parallel open pinnæ. The point or upper part of three of these dissected parallel leaves is represented in fig. 1; this division is by more or less distant segments, which, opposite or alternate, are of various size, narrowly lanceolate pointed, decurrent at the base, and thus connected by a wing along the rachis. As seen at the base of the segments of the middle leaflet of fig. 1, the wing along the borders is nerved like the divisions or leaflets. The middle vein of these segments is thick; the secondary veins close, parallel, turned up in passing to the borders, simple, but joined in various directions by oblique nervilles, forming a mixed, angular, square, or polygonal areolation. The nervation and areolation were exactly copied for fig. 2 of Pl. VI of this memoir, but the wood-cut does not expose it in its details. Some of the specimens show the upper part of three parallel leaves whose tops are on a right line and more exactly like the upper pinnæ of a fern than the specimen figured in the Cret. Flora.

My first opinion in regard to the relation of these remarkably fine vegetable remains was that they represented some kind of an old extinct type of *Filices*. I even supposed that, considering the peculiar disposition of the leaflets and their nervation, we had here something like a transient form between the ferns and plants of a higher order. The sections of the leaves are similar to those of some species of fossil ferns, *Stenopteris desmomera*, Sap.,* for example, which, from the remarks of the author, is without relation to any living fern; also like the fragment described by Debey and Ettingshausen† under the generic name of *Monheimia*, which not only have a similar division of leaves or pinnæ, but, as seen in fig. 6, a nervation of an analogous character, the numerous parallel secondary veins curving up along the borders, some of them united by oblique veinlets. A mere sketch of one of my specimens sent to Count Saporta gave him the same impression in regard to its reference to ferns. But the areolation was not represented upon it, and the characters of the areolation especially remove the species to another order of vegetables, the *Proteaceæ*. Indeed species of *Lomatia* have the leaves pinnately laciniate, with the divisions alternate, decurring along the middle nerve or rachis, and a nervation and areolation somewhat comparable to those of the fossil species. I have therefore abandoned the first reference, and, following the opinion of the celebrated author from

* Plantes fossiles des lits de poissons de Cerin, by Count Saporta, p. 22, Pl. XIV.
† Urweltlichen Acrobryen, p. 33, Pl. IV, figs. 1-10.

which this species is named, I have placed it with the *Proteaceæ*. I am, however, still uncertain in regard to the true relation of these remarkable remains. There is, as said above, in the position and the subdivisions of the leaflets a remarkakle affinity with those of some species of ferns, and at the same time a discrepancy with what is remarked in the segments of the leaves of *Lomatia* and other species of laciniate *Proteaceæ*. In the fossil plant the decurrent base forming a wing of the rachis, has the same character of nervation as the leaflets, while in the basilar segments of the *Proteaceæ* the winged part is generally without visible veins, or rather veined lengthwise. Moreover, there seems to be a kind of anomaly in the presence of plants of the so called Australian types in a vegetable group where the characters of the present American flora are so predominant, or in connection with species of *Fagus*, *Liriodendron*, *Platanus*, etc. The leaves described under the name of *Proteoides* are as yet not positively referable to the *Proteaceæ*, their nervation being still unknown; and thus we should have to admit this *Lomatia ?* as the only representative of an Australian type among a large number of forms of different affinities.

This species has been found originally in very fine specimens by Prof. B. F. Mudge, in Southern Kansas. I have lately received a small fragment only from Mr. H. C. Towner, found near Clay Center, Kansas.

PROTEOIDES DAPHNOGENOIDES, Heer, Cret. Flora, p. 85, Pl. XV, figs. 1, 2.

Leaves ovate-lanceolate toward the base, gradually tapering upward to a long scythe-shaped acumen, entire, smooth and coriaceous; middle nerve narrow; secondary veins obsolete, few, ascending at a very acute angle from the middle nerve and following the borders.

PROTEOIDES ACUTA, Heer, Cret. Flora, p. 86, Pl. XV, fig. 3; Pl. XXVIII, fig. 13.

Leaves coriaceous, linear-lanceolate, narrowed to the base and gradually so to a scythe-shaped point; borders undulate; middle nerve strong, secondary veins obsolete.

PROTEOIDES GREVILLEÆFORMIS, Heer, Cret. Flora, p. 86, Pl. XXVIII, fig. 12.

Leaf coriaceous, small, enlarged above the base, linear-lanceolate, flexuous; borders entire; middle nerve thick; secondary veins alternate, thin, acrodrome, ascending nearly parallel to the borders and slightly curving inward.

EMBOTHRITES ? DAPHNEOIDES, Lesqx., Cret. Flora, p. 87, Pl. XXX, fig. 10.

Leaf coriaceous, polished, oblong, narrow, gradually narrowed downward and decurrent to the enlarged middle nerve; borders slightly reflexed; nervation pinnate; lateral veins opposite, close, at a very acute angle of divergence.

This fragment of leaf is of an uncertain attribution.

ASARINEÆ.

ARISTOLOCHITES DENTATA, Heer, Cret. Flora, p. 87, Pl. XXX, fig. 6.

Leaf nearly round, thickish, split from the base of the petiole to the borders, undulate-crenate, three-nerved; secondary veins curving and anastomosing in large, oval, angular meshes.

GAMOPETALEÆ.

BICORNES.

ANDROMEDA PARLATORII, Heer, Cret. Flora, p. 88, Pl. XXIII, figs. 6–7; Pl. XXVIII, fig. 15.

Leaves lanceolate, narrowed to the base and decurring along the petiole by a narrow border, entire; middle nerve thick; secondary veins at an acute angle of divergence, parallel, camptodrome.

ANDROMEDA AFFINIS, sp. nov. Pl. III, fig. 5.

Leaf thickish, narrowly lanceolate, narrowed to a long acumen, gradually decreasing toward the base; borders entire; middle nerve comparatively thick; lateral veins close, parallel, subequidistant, in an acute angle of divergence; areolation minute.

The leaf five and one-half centimeters long, eleven millimeters broad in its widest part, the middle, is gradually equally narrowed down to the petiole and up to a long narrow acumen, and entire; the secondary veins are numerous, simple, at an angle of divergence of 30°, parallel, rather obsolete, though thickish, scarcely curving in ascending close to the borders, camptodrome; the areolation is in round or quadrate-polygonal minute areolæ. It is closely allied to the former species, if not a variety of it.

HABITAT.—Spring Cañon, where it is mixed with fragmentary leaves of *Andromeda parlatorii*; the horizon of this locality is not geologically determined, *Dr. F. V. Hayden.*

DIOSPYROS AMBIGUA, Lesqx., Cret. Flora, p. 89, Pl. VI, fig. 6.

Leaf coriaceous, narrowly oval, narrowed near the point into a short slightly obtuse acumen; borders entire; nervation pinnate, camptodrome.

DIOSPYROS ROTUNDIFOLIA, Lesqx., Cret. Flora, p. 89, Pl. XXX, fig. 1.

Leaf subcoriaceous entire, nearly round, pinnately nerved; secondary veins parallel, camptodrome; surface undulate, polished.

POLYPETALEÆ.

UMBELLIFLORÆ.

ARALIA TRIPARTITA, spec. nov. Pl. I, fig. 1.

Leaf small, three palmately divided to two-thirds of its length; lobes equal, linear obtuse, entire; secondary nervation obsolete.

The leaf is seven centimeters long, six centimeters wide between the points of the lobes, which diverge in an angle of 25°; cuneate to the base, which apparently descends a little lower than the point of union of the primary veins, where it is broken; lobes four and one-half centimeters long, one centimeter broad, nearly exactly linear, abruptly rounded at the point, with perfectly entire borders and obtuse sinuses; primary nerves thin but distinct, secondary veins totally obsolete. The surface is smooth and the consistence of the leaf coriaceous.

This small leaf appears like an original simple representative of a type of *Aralia* predominant in numerous diversified forms in the Dakota group.

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

ARALIA CONCRETA, spec. nov. Pl. IV, figs. 2, 3, 4. Cret. Flora, Pl. XXIX, figs. 8, 9.

Leaves small, very thick, coriaceous, palmately five-lobed to below the middle, cuneate and curving to the petiole; very entire; primary veins three, from the top of the petiole or from a little above the border base of the leaves, the lateral ones forking; all thick, flat, and deep, preserving the same size to the top of the pointed lobes.

These leaves vary in diameter from five and one-half centimeters to eight, across the point of the lobes, not as long as broad; cuneate to the thick petiole, which they reach by a more or less abrupt curve; divided to below the middle in three to five equal oblong lanceolate-pointed or obtusely-pointed lobes, separated by narrow sinuses and very entire. The primary veins are very thick and flat, the lateral ones forking above the point of union, as it is the case in all the forms of this type; the secondary nervation is totally obsolete, as in the former species. This, however, differs from it, not only by the subdivision in five lobes, but also by the remarkably broad middle nerve.

I had originally separated as a different species, the leaf, fig. 4, under the name of *Aralia semi-orbiculata*, on account of its remarkable half-round base; of the difference of size of some of the lobes and of the acute sinuses. As the primary nervation is the same and the secondary one as obsolete as in the other leaves, the coriaceous consistence being also a common character, I regard it as probably a mere variety. This appears the more rational, as all these leaves come from the same locality.

HABITAT.—Clay Center, *H. C. Towner*.

ARALIA TOWNERI, spec. nov. Pl. IV, fig. 1.

Leaves large, coriaceous with polished surface, five-lobed to below the middle; lobes oblong, obtuse, or obtusely pointed, entire; primary nerves three from the top of the petiole, the lateral ones forking above the base; secondary veins on an open angle of divergence, camptodrome.

This fine leaf of which a part only is figured, is, as seen from another specimen, fifteen centimeters long, from the top of the petiole, and twenty to twenty-four centimeters broad between the point of the lobes which, descending much lower than the middle, are seven to ten centimeters long and three to three and one-half centimeters broad. The primary nerves are comparatively narrow, not half as thick as in the former species and gradually narrowing to the point; the form of the lobe is oblong, the point slightly obtuse, the sinuses also obtuse. The secondary veins, distant and on an open angle of divergence pass toward the borders in curves and follow them in festoons, anastomosing by nervilles with those above; they are generally separated by tertiary shorter veins, forming by their ramifications in more or less oblique directions square or polygonal angular large meshes. Though the general outline and the division of these leaves are similar to those of the former species, they evidently differ, by narrow, primary veins, less coriaceous substance, polished surface, and distinct areolation. The type is, however, the same.

HABITAT.—Same as the former, *H. C. Towner*.

ARALIA QUINQUEPARTITA, Lesqx., Cret. Flora, p. 90, Pl. XV, fig. 6.

Leaves membranaceous, three-nerved from a distance above the base; five-lobed by the forking of the lateral primary nerves; lobes oblong or oblanceolate, somewhat narrowed downward, distantly dentate toward the point; base of the leaves deltoid cuneiform.

We have now of this species, described in the Cret. Flora from a mere fragment, a far better specimen. It represents a leaf sixteen centime-

ters long from the point where the base joins the petiole to the top of a large lateral lobe preserved in full; its base narrowed in a curve, and decurrent. It is deeply divided in six narrow oblanceolate lobes narrowed toward the sinuses, dentate from the middle upward, the lower lateral ones nearly entire; the middle ones twelve centimeters long, two centimeters broad in the middle, and only one centimeter near the sinuses. The distance between the points of the external lobes is nine to ten centimeters. The primary lateral nerve on one side forks twice and therefore forms three divisions or lobes, while on the other side it forks once only, and therefore has two divisions, and thus the leaf is six-lobed, though the normal division of the leaves is by five. Though thickish, they are of a rather membranaceous consistence and smooth. The lateral veins, though obsolete, appear very thin, distributed about as in the following species, but on a broader angle of divergence and more curved in passing up to the borders. From the base of the lobes downward no trace of nervation is observed.

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

ARALIA SAPORTANEA, sp. nov. Pl. I, figs. 2 and 2ª.

Leaves palmately five-lobed to above the middle, narrowed in a curve or broadly cuneate to a long, slender petiole, fan-shaped in outline; lobes of different size, lanceolate, obtusely pointed, distantly dentate; nervation craspedodrome.

The leaves are variable in size, from nine to eighteen centimeters long without the petiole, and from nine to twenty centimeters broad between the points of the external lobes; lobes lanceolate, gradually tapering to an obtuse point, distantly obtusely dentate; the lateral ones gradually shorter than the middle one, which, in the largest of our specimens, is twelve centimeters long from the point to the obtuse sinuses; leaves three-nerved from the base; lateral nerves forking once, and lateral lobes oblique at an acute angle of divergence. The nervation and areolation are perfectly distinct in all the specimens, and its characters identical; the secondary veins, at an acute angle of divergence of thirty degrees, curve in passing up to the borders, where they enter the teeth, and are then craspedodrome, while the lower ones more generally follow the entire border base of the lobes; the nervilles are strong, nearly continuous, branching at right angle, and forming by this kind of division small square or equilateral areolæ.

The leaves which represent this species are of a beautiful and elegant pattern; the small ones still more finely shaped by the distribution of the lobes, which are acutely pointed, and at a more open angle of distribution toward each other. They represent, perhaps, a different species; but I could not find a persistent and distinct character, neither in the form nor in the nervation, to separate them. By the texture, which though thickish is not membranaceous, by the form of the broader lobes not narrowed toward the sinuses, by the distinct nervation, the point of union of the primary nerves at the non-decurrent base of the leaves, the species is evidently different from the former, though found at the same locality. The relation of these *Aralia* leaves to the *Sassafras* (*Araliopsis*), especially to *S. mirabile*, is easily remarked; there is, however, a great difference in the characters of nervation and areolation, clearly perceivable in comparing our fig. 2ª with the leaves in Cret. Flora, Pl. XI, fig. 1, and Pl. XII, fig. 1. The habitat of these *Aralia* species shows once more the peculiar grouping of leaves of same or analogous characters in a same locality. *Aralia quinquepartita* and *A. Saportanea* are from the south of Fort Harker, Kansas, while the

two species with entire leaves, *A. Towneri* and *A. concreta*, were found near Clay Center, except *A. tripartita*, which also is from Fort Harker. These five new types of Cretaceous plants proves the richness of this remarkable flora, and their local distribution assures for future explorations a rich field for new discoveries.

HABITAT.—South of Fort Harker, *Chs. Sternberg.*

HEDERA OVALIS, Lesqx., Cret. Flora, p, 91. Pl. XXV, fig. 3, and Pl. XXVI, fig. 4.

Leaves coriaceous, entire, oval, rounded at the point, narrowed to the base, pinnately nerved; middle nerve thick; secondary veins alternate, irregular in distance, more or less numerous; areolation in large irregular meshes.

These leaves have an evident relation to those published by Professor Heer under the name of *Chondrophyllum Nordenskiöldi* and *C. orbiculatum*, from the upper Cretaceous of Greenland Foss. in his Flor., Arct., III, pp. 114 and 115, Pl. XXXII, figs. 12 and 13, reconstructed from fragments. When the specimens are compared, they may prove to be the same species, for, though I have formerly considered the leaves as representing one species only, for the fragments show a great diversity in the characters of the nervation, there is, however, too great a difference between the multiple much-divided secondary veins on a broader angle of divergence of Pl. XXV, fig. 3, and the more simple nervation of Pl. XXVI, fig. 4, to permit considering them as representing the same species.

HEDERA SCHIMPERI sp. nov. Pl. VII, fig. 5.

Leaf subreniform, broader than long, rounded at the top, abruptly narrowed or nearly truncate to a short petiole, three-nerved from above the base; lateral veins curving in various directions toward the borders, anastomosing by thick branches and nervilles with the divisions of the short, distant secondary veins, curving along the borders and entering by short veinlets the distant, slightly-marked denticulations of the borders.

A fine leaf of coriaceous substance, six centimeters long without the petiole (which is only seven millimeters long and enlarged at its base), six and one-half centimeters broad, with borders minutely denticulate, the teeth at different distances and of various size, and a trifid nervation from a short distance above the border base of the leaf; the lateral veins curve, the one inside toward the middle nerve, the other outside toward the border and branching nearly at right angle, they anastomose with nervilles or divisions of the secondary veins and form an areolation irregular and mixed with angular, square, or polygonal meshes. This areolation partakes of the characters of that of the former species. It is somewhat analogous to that of *Greviopsis tremulæfolia*, and of *Cissus ampelopsidea Sap.*, and recognizable also in the following.

HABITAT.—South of Fort Harker, *Chs. Sternberg.*

HEDERA PLATANOIDEA, sp. nov. Pl. III, fig. 3.

Leaf small, broadly ovate, truncate at the base, round at the top, short petioled, entire; nervation trifid from a short distance above the base; primary veins craspedodrome.

This leaf five centimeters broad, four and one-half centimeters long without the short enlarged petiole, has its borders entire, though the primary and secondary veins reach to the borders and enter them; the two lateral primary nerves force the border slightly outside, and the leaf appears thus sublobate or enlarged in the middle; the lower branches

of the lateral nerve follow the borders in festoons along the base of the leaf, and, as in the former species, there is a pair of marginal veinlets under the primary nerves, and at right angle to the midrib. The areolation is mostly in square or angular large meshes, less irregular than in the former species. From the form of the leaf, the short inflated petiole, and the character of the areolation, the leaf appears referable to the same generic division as the former. It differs, however, by the primary and secondary veins joining the borders, and not curving inside of them. These two leaves appear to be transitional in their characters between the *Araliaceæ* and the *Ampelideæ*.

HABITAT.—South of Fort Harker, *Chs. Sternberg.*

AMPELIDEÆ.

CISSITES, Heer.

Under this generic name, Professor Heer has described in the *Phyllites du Nebraska*, p. 20, Pl. II, figs. 3 and 4, fragment of a leaf which seem to have a close affinity to those which I describe under this same division. These leaves, enlarged on the sides and above the middle by the extension of primary lateral veins, are either deltoid, pointed, or round, or lobate at the top, and broadly rounded and attenuated to the base. Their primary nervation, trifid from above the base-border of the leaves, is of the same type as that of the *Sassafras* (*Araliopsis*), and the secondary veins, all camptodrome, curving along the borders in successive bows, have also an undeniable affinity with the same group. But they evidently differ by the less distinct trilobate division of the leaves, the broader base, the smaller size, and the general facies. It is evident, however, in comparing the leaves described under this generic name, that closely related as they are between themselves, they are altogether allied by some of their characters to the *Araliceæ*.

CISSITES HARKERIANUS. Pl. VII, figs. 1 and 2.

Sassafras (*Araliopsis*) *Harkerianum*, Lesqx., Cret. Flora, p. 81, Pl. XI, fig. 4.

Leaves coriaceous, round in outline, subtrilobate, broadly cuneate to the base; nervation trifid from above the border base; lateral primary veins branching outside; secondary nerve simple, distant, mostly opposite camptodrome or craspedodrome.

The two leaves figured here are smaller than that of Plate XI, fig. 4, of the Cretaceous Flora; but there is not any marked difference in the outline and the nervation; we have, moreover, specimens showing leaves of intermediate size. The nervation is more or less pronounced, according to the face exposed by the specimens. This and the following form might be indifferently referred to *Sassafras* (*Araliopsis*) or *Cissus*.

CISSITES AFFINIS.

Platanus affinis, Lesqx., Cret. Flora, p. 71, Pl. IV, fig. 4, Pl. XI, fig. 3.

Leaves coriaceous or subcoriaceous, round, polygonal in outline, subtrilobed, rounded and narrowed to the petiole, broadly deltoid to the point; borders undulate; distantly short dentate; nervation trifid from the base or from a little above the borders.

From the comparison of a number of specimens, and especially from the discovery of one representing, by the splitting of the stone, both sides of the leaf, I have ascertained that the one represented, Plate IV, fig. 4, whose veins are thin, and the surface scarcely furrowed by the

nervation, is of the same species as that of Plate XI, fig. 3, whose surface is deeply cut by broad nerves and secondary veins. In this form, the secondary veins are sometimes all craspedodrome, sometimes mixed.

CISSITES ACUMINATUS, sp. nov., Pl. VIII, fig. 1.

Leaf deltoid from the middle to the acuminate point, rounded and subtruncate to the petiole, subtrilobate, entire coriaceous; nervation trifid from the base.

This fine leaf, though of the same type as those described under the two former specific divisions, differs evidently by its form, its entire borders, and its secondary veins parallel, close to each other, all camptodrome. It is about eight centimeters long without the petiole, which was apparently long and slender; seven centimeters broad between the two points of the primary lateral nerves, where it is enlarged into a slightly marked acute lobe, and wherefrom it is broadly deltoid to the acuminate point. Comparing it to the fine small leaf of *Sassafras Mudgei* in Cret. Flora, Pl. XXX, fig. 7, we easily recognize a likeness of characters in the form and the nervation, which proves also the relation of this *Cissites* to the *Sassafras* or the *Araliaceæ.*

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

CISSITES HEERII, sp. nov. Pl. VI, fig. 3.

Leaf fan-shaped in outline, rounded and cuneate to the base, enlarged above the middle, divided in the upper part into five acute nearly equal lobes; nervation trifid from above the base; lower secondary veins ascending to the point of the intermediate lobes, the others all camptodrome like their divisions.

The base of this leaf is destroyed; but its outline is clearly defined by the border of the preserved part, and the direction of the lateral primary vein. The leaf broadly cuneate toward the base, is slightly contracted a little above, and hence is rounding to join the petiole; the two lateral primary nerves ascend to the point of a lower acute lobe, as also the lower secondary veins, appearing, with the middle nerve, like five branches of a five-lobed fan-like leaf. The lobes are equal, separated by half-rounded sinuses, and acutely pointed. Except that the two lower secondary veins ascend to the points of two lobes, the nervation is of the same type exactly as in the former species. The affinity of these two leaves is therefore evident. It is, however, certain that this one cannot be now compared to *Sassafras* (*Araliopsis*), nor to *Aralia*, and it therefore authorizes the separation of this group, which by its characters, seen in this last species, is allied to the *Ampelideæ*, especially to *Cissus.*

HABITAT.—Near Fort Harker, Kansas, *Chs. Sternberg.*

CISSITES CYCLOPHYLLA, Lesqx.

Populites cyclophylla?, Heer,—Cret. Flora, p. 59, Pl. IV, fig. 5, and Pl. XXIV, fig. 4.

Leaves round, entire, subcoriaceous, with slightly undulate borders, round or truncate to the long slender petiole; nervation subtrifid or pinnate from the base; lateral veins straight to the borders, craspedodrome, the lowest branching.

I am not positive in regard to the specific identity of the two leaves referred to this species. Fig. 5 of Pl. IV has the veins on a more acute angle of divergence, it being less enlarged on the sides; fig. 4 of Pl. XXIV, has under the lower pair of lateral nerves a thick marginal vein in right angle to the mid-rib; in both, however, the veins and their divisions enter the borders, and the nervilles, which join them in right

angle, are thick, undulate, at equal distance, and generally simple. It has been remarked already, that the characters of the veins, all craspedodrome, favor a separation of these leaves from the genus *Populus*, though the round form and long slender petiole give them the appearance of poplar leaves.

CISSITES OBTUSUM.

Sassafras obtusum, Lesqx., Cret. Flora, p. 81, Pl. XIII, figs. 2–4.

Leaves thin, long petioled, flabelliform, three-obtusely lobed, entire or undulate on the borders, broadly cuneate or narrowed to the petiole, three-nerved from a little above the border base; secondary veins parallel, camptodrome.

If the relation of these leaves to the *Araliaceæ* is marked by the three-lobate form and the nervation, their affinity to the *Ampelideæ* is indicated also by the thinner substance of the leaves, and the long, slender petiole. Like many other Cretaceous leaves, they are of a mixed character, and their reference uncertain. Except by their thin substance and long petiole, they are indeed very similar to fig. 4, of Pl. XI, of the Cret. Flora, representing *Cissites Harkerianus*. By the other characters they relate to the following generic division.

AMPELOPHYLLUM, Lesqx.

Leaves ovate or obovate obtuse entire, narrowed to a long petiole or subcordate; palmately three-nerved from above the base; nervation craspedodrome.

AMPELOPHYLLUM ATTENUATUM, sp. nov. Pl. II, fig. 3.

Leaf broadly obovate, enlarged upward from the cuneate base, rounded at the top, entire, subcoriaceous; lateral primary nerve from a distance above the base flexuous, branching outside and inside, ascending to the borders.

This fine leaf is six and one-half centimeters long without the petiole, nearly six centimeters wide above the middle, rounded at the top, undulate by the slight protuberance of the veins, three-nerved from a distance (one centimeter) above the narrowed base, with two pairs of distant alternate secondary veins, reaching the borders like the primary nerves, either directly or by their branches. Connected by nervilles at right angles, and also divided in very oblique veinlets, they form irregular quadrate large meshes, and pass up in right angle to the borders. There is under the base of the primary nerves one or two pairs of marginal veinlets in the same degree of divergence as the other veins, 40° to 50°.

The form of this fine leaf and its nervation also are peculiar, and of a character analogous to that of some leaves described under the generic name of *Greviopsis* in the Sezane Flora by Saporta; there is, however, a marked difference in the primary nervation and in the entire borders of the leaves. The two lower pairs of veinlets give also to this leaf an affinity with *Credneria*, and especially with the small entire leaves of *Platanus Heerii* as figured in this memoir, Pl. VIII, fig. 5; The secondary and tertiary nervation are, however, of a different character.

HABITAT.—South of Fort Harker, Kansas, *Chs. Sternberg*.

AMPELOPHYLLUM OVATUM.

Celtis? ovata Lesqx., Cret. Flora, p. 66, Pl. IV, figs. 2, 3.

Leaves thickish, membranaceous, obtuse or truncate at the point, gradually enlarged toward the truncate or subcordate base, abruptly curving to a long petiole, borders entire, undulate three-nerved from the base, secondary veins two or three pairs, at a distance from the primary ones, all craspedodrome.

These two leaves evidently represent the same species, but their reference to this division is not positive. As in the former species, the lower veins are irregularly divided, the fibrillæ distinct, at least in fig. 3, which has also one pair of marginal veinlets; the subdivision of the veins along the borders is, however, obsolete, though the veinlets appear to pass up into them.

HAMAMELITES KANSASEANA. Pl. VII, fig. 4.

Alnus Kansaseana, Lesqx., Cret. Flora, p. 62, Pl. XXX. fig. 8.

Leaves membranaceous, oval or obovate rounded or subcordate to the base, obtuse, undulate, pinnately nerved; veins parallel, ascending to the borders in an acute angle of divergence, branching outside, craspedodrome except the lowest, which is more open and curving along the borders.

The specimen figured here is more complete than the one described in the Cret. flora. No traces of denticulation are observable along the borders, but regular deep undulations, which near the point pass to obtuse teeth. Except the two lower pairs of veins, all the others and their divisions reach the borders; they are parallel, under an angle of divergence of 40°, equidistant and deeply marked. In this specimen the middle nerve passes under the border-base of the leaf, which is rounded; while in the other fragment figured in Cret. Flora, the border base is cordate, and curves on both sides to the middle nerve.

From the opinion of Saporta, the author of the genus in the Sezane flora, the reference of these leaves to the Hamamelites appears legitimate.

HABITAT.—Fort Harker, Kansas, *Chs. Sternberg.*

HAMAMELITES QUADRANGULARIS.

Alnites quadrangularis, Lesqx., Cret. Flora, p. 62, Pl. IV, fig. 1.

Leaf subcoriaceous, small, broadly rhomboidal in outline, with obtuse angles; borders entire, undulate, rounded to a short petiole (broken); nervation pinnate; veins parallel, craspedodrome, except the lower pair mere marginal veinlets.

The leaf, whose areolation is not distinct, has apparently the same characters of nervation as in the former species, differing merely by its shape and its size. Though the veins are thicker it may represent the same species.

POLYCARPICÆ.

MAGNOLIA TENUIFOLIA, Lesqx., Cret. Flora, p. 92, Pl. XXI, fig. 1.

Leaf large, oblong, rounded upward to an obtuse point? (broken), narrowed in a curve to a short slender petiole; middle nerve straight, narrow; lateral veins alternate, on a broad angle of divergence, slender, undulate, deflexed near the point of insertion to the middle nerve.

MAGNOLIA ALTERNANS, Heer, Cret. Flora, p. 92, Pl. XVIII, fig. 4.

Leaves subcoriaceous ovate-lanceolate or elliptical, obtusely pointed, entire

tapering to the petiole; secondary veins numerous, parallel, alternately shorter and longer, camptodrome.

The specimen figured in the Cretaceous Flora is poor. Until recently I had not seen any better, neither of this nor of the following species. Both have been more commonly found in Nebraska than in Kansas.

MAGNOLIA CAPELLINI, Heer, Phyllites, p. 21, Pl. III, figs. 5 and 6.

Leaves coriaceous, broadly oval, very entire; secondary veins at an acute angle of divergence, curving to the borders, camptodrome.

Specimens referable to this species were received with others of *M. alternans* from Mr. Sternberg; they are all more or less undistinct and fragmentary. The two forms seem to pass from one to the other by intermediate degrees, especially in the width of the leaves, so that it is difficult to find the point of separation between them. The State cabinet of New Jersey has a large number of specimens representing both species, some of them appearing indifferently referable to the one or to the other. But here, also, all the specimens are more or less fragmentary and indistinct.

LIRIODENDRON MEEKII, Heer, Phyllites, p. 21, Pl. IV, figs. 3 and 4.

Leaves panduriform (violin-shaped), emarginate at the top, bilobate, lobes obtuse, secondary veins branching.

This species is rare in the Cretaceous, at least in Kansas. This year I have received, for the first time, a small specimen discovered in that State by Professor Mudge. The leaf is of a thin texture, oblong in outline, short petioled, deeply emargined, the upper part of the leaf being thus bilobate; lobes oblong-obtuse, one centimeter broad, separated from the lower lobes by an obtuse narrow sinus scarcely four millimeters broad; lower lobes eighteen millimeters long from the border of the sinus, oblong obtuse, diverging nearly at right angle; base of the leaf rounded to the petiole. Considering that in the leaves of the present *Liriodendron tulipifera* the emargination of the leaves and the lateral lobes are very variable in size, it is proper to refer this leaf to the species described by Heer, for, except the length of the lobes, it has the same characters. The small leaf is without the petiole, thirty-eight millimeters long, and just the same width between the top of the lateral lobes.

LIRIODENDRON INTERMEDIUM, Lesqx., Cret. Flora, p. 93, Pl. XX, fig. 5.

Leaf large, trilobate; upper lobe deeply emarginate-lobed, secondary veins thin, simple, parallel.

Since the description of this and the following species, published in 1868, I have not found and not received any specimens referable to them. They would be very acceptable, for we know these fine species merely from fragments.

LIRIODENDRON GIGANTEUM, Lesqx., Cret. Flora, p. 93, Pl. XXIII, fig. 3.

Leaf very large, bilobed; upper lobe deeply emarginate, segments oblong obtuse, with four parallel secondary veins.

This mere lobe of a leaf is about twelve centimeters long, and, therefore, would indicate a leaf at least twenty-four centimeters broad between the points of the upper divisions, or nearly one foot broad, and as long. *Liriodendron tulipifera* has in favorable localities leaves as large as those indicated by this fragment.

MENISPERMITES OBTUSILOBUS, Lesqx., Cret. Flora, p. 94, Pl. XXV, figs. 1, 2; Pl. XXVI, fig. 3.—Pl. VII, fig. 3.

Leaves coriaceous, large, broadly deltoid, either shorter, nearly round in

outline, or longer, narrowed to an obtuse point, peltate from near the base, subtrilobate, five-palmately nerved, deeply undulate.

The fig. 3 of Pl. VII of this memoir has been given here on account of the good preservation of the leaf clearly exposing the characters of the genus. Comparing it with the figures of the same species in the Cret. Flora, its characters appear evidently identical. From the large leaf, fig. 1, Pl. XXII, it differs in no manner whatever except by its size, showing, therefore, that this fine leaf is, as remarked, a mere variety of the normal form. But more than this, by comparison of the distribution of the veins and of the essential characters of the nervation in the following species, it proves their relation to this generic division, which has two definite sections, represented one by lobate, the other by entire leaves.

HABITAT.—Clay County, *H. C. Towner.*

MENISPERMITES SALINENSIS, Lesqx., Cret. Flora, p. 95, Pl. XX, figs. 1, 4.

Leaves thickish, membranaceous or subcoriaceous, triangular in outline, deeply undulate-lobed, or palmately five-lobed from the border base, which is enlarged and truncate.

MENISPERMITES ACERIFOLIUS, Lesqx., Cret. Flora, p. 96, Pl. XX, figs. 2 and 3.

Leaves small, triangular in outline, palmately obtusely three-lobed, wedge form, or abruptly narrowed to the base; nervation three-palmate.

MENISPERMITES POPULIFOLIUS, sp. nov. Pl. V, fig. 3.

Leaf broadly ovate, obtuse, subcordate at the base, five-palmately nerved from the border base, primary nerves in an open angle of divergence, dividing on the lower side, like the secondary veins, all camptodrome.

The leaf is broadly ovate, perfectly entire, coriaceous, five and one-half centimeters long, and as broad below the middle, where it is somewhat enlarged; five palmately nerved from the base, the lateral veins diverging about equally in an angle of 30° from each other, so that the inner one ascends to the two-thirds of the leaf, the second to below the middle, and the basilar veinlets are in right angle to the midrib. The primary veins branch on the outside, anastomose with nervilles, and the exterior ones curve along and follow the borders; the secondary veins are at an open angle of divergence of 60°, separated by strong nervilles at right angle to the middle nerve. The areolation is obsolete.

HABITAT.—South of Fort Harker, Kansas, *Chs. Sternberg.*

MENISPERMITES OVALIS, sp. nov. Pl. V, fig. 4.

Leaf narrowly oval oblong, obtuse rounded at the base; five-palmately, nerved; lateral veins on an acute angle of divergence, the inner ones ascending to near the top, branching outside; branches numerous, parallel, curving along the border in multiple festoons.

This fine leaf, preserved nearly entire, is subcoriaceous, seven and one-half centimeters long, three and one-half centimeters broad, nearly exactly oval-oblong, perfectly entire and rounded to the base. The palmately five nervation is less definite than in the former leaf; the two internal lateral veins are as strong as the middle nerve, curve gradually in the same direction as the borders, and, near the top, join the branches of the midrib, with which they anastomose in curves; the outside lateral veins are thinner and shorter; they ascend nearly parallel to the borders, but disappear in the middle of the leaf in anastomosing with branches of the inside primary veins. In comparing this nervation with that of the

former species and also with that of the other leaves referred to this division, its identical type will be easily recognized and its reference to this genus found appropriate.

Under the name of *Daphnogene Kanii*, Professor Heer has published in the Arctic Flora, 1, p. 112, Pl. XIV, from the Miocene of Greenland, leaves which by form and nervation are closely related to this Cretaceous species. In the flora of Gelinden by Saporta and Marion, fragments of leaves of the same character are referred to the *Menispermaceæ* and described under the generic name of *Cocculus*. The Cretaceous form here described is intermediate between the Tertiary species and those described here from the Dakota group.

HABITAT.—Near Clay Center, Kans., *H. C. Towner.*

MENISPERMITES CYCLOPHYLLUS, sp. nov. Pl. VI, fig. 4.

Leaf subcoriaceous, entire, nearly round, peltate from near the middle, deeply concave, palmately five nerved; inner lateral veins curving inside toward the point; the outer ones open nearly at right angle to the middle nerve, all dividing by open straight branches; basilar veinlets three, passing down and curving along the borders.

The first of these leaves figured here is not quite as well preserved as a larger specimen obtained lately. The essential characters are, however, distinctly marked. Excepting the modification in relation to the form of these leaves, and the point of attachment of the petiole, the nervation is of the same type as in the former species As observed upon the larger specimens, three or four veinlets pass downward from the lower part of the point of attachment of the petiole, curving on each side and following the borders in festoons, like marginal veinlets. The tertiary nervation, which is distinct and as marked upon the upper part of the figure, is exactly of the same type as in the former species, the veinlets nearly at right angle or slightly oblique to the secondary veins, forming a double series of outside curves like superposed arches, the last row following the borders in festoons. The leaf figured as marked above is concave to the round point of attachment of the petiole, which passes down into the stone, leaving an opening like the pipe of a funnel. In the larger leaf, which is ten centimeters broad and eight long, the depression is not as marked and the surface is nearly flat. On this specimen the primary veins and their branches pass up to near the borders before dividing, and thus have a nervation remarkably similar to that of *Menispermites Salinensis*, as represented in Cret. Flora, Pl. XX, fig. 1.

HABITAT.—Kansas, near Fort Harker, the first leaf, *Chs. Sternberg.* Near Clay Center, the largest specimen, *H. C. Towner.*

MALVACEÆ.

STERCULIA LINEARILOBA, sp. nova.

Leaf truncate to a short thick petiole, large, divided to near the base in five linear-entire, narrow, obtusely-pointed lobes about equally diverging, from acute sinuses.

I know this fine leaf only from a sketch communicated by the owner of the specimen. It is seventeen centimeters broad between the points of the lower lobes, which are in right angle to the middle one, eleven centimeters long from the top of the petiole to the point of the middle lobe, which is eleven centimeters long from the sinuses; five-palmately nerved from the base; lobes nearly linear, narrowed into a short point,

entire; nerves very thick, secondary veins and areolation obsolete. This leaf may be referable to *Aralia*, but it appears more evidently related to *Sterculia* by its truncate base and its narrow linear lobes.

HABITAT.—Near Clay Center, *H. C. Towner.*

TILIACEÆ.

GREVIOPSIS HAYDENII, Lesqx., Cret. Flora, p. 97, Pl. III, figs. 2, 4; Pl. XXIV, fig. 3.

Leaves large, broadly ovate, tapering up to a point, more or less abruptly narrowed to the base; borders equally denticulate from below the middle; nervation irregularly pinnate or abnormally five-palmate, craspedodrome.

In regard to these leaves, whose attribution is not positively known, Count Saporta remarks that by their facies they resemble leaves of *Corylopsis*, a generic division of the *Hamamelidæ*, especially represented in the Japan flora; the attribution would be therefore a natural one. These leaves, however, appear equally related by some of their characters and by their facies to the *Tiliaceæ*.

ACERACEÆ.

NEGUNDOIDES ACUTIFOLIUS, Lesqx., Cret. Flora, p. 97, Pl. XXI, fig. 5.

Leaves irregularly cut; leaflets thin, lanceolate-pointed or enlarged lobate, with acuminate lobes, pinnately veined; veins camptodrome.

No other fragments referable to this have been discovered. The true character of the leaves represented by the fragments is uncertain.

CELASTRACEÆ.

CELASTROPHYLLUM ENSIFOLIUM, Lesqx., Cret. Flora, p. 108, Pl. XXI, figs. 2, 3.

Leaves very thick and coriaceous, linear, abruptly contracted to the base by a round curve, broadly deltoid-pointed, borders undulately crenate or merely undulate; nervation pinnate, secondary veins close, parallel camptodrome, diverging in acute angle from the thick middle nerve.

AQUIFOLIACEÆ.

ILEX STRANGULATA, sp. nov. Pl. VIII, fig. 3.

Leaf coriaceous, narrow, panduriform or strangled in the middle to a small angular lobe; rounded and narrowed to the petiole, entire toward the base; upper part enlarged oval (point broken), borders irregularly, distantly, obtusely dentate, secondary veins close, nearly at right angle to the middle nerve, irregularly camptodrome.

This leaf is about five and one-half centimeters long without the petiole, which measures one and one-half centimeters; its broadest part above the petiole, as below the point, is not more than twelve millimeters, and in the middle, where it is contracted, two millimeters only. Its texture is thick; the surface rugose; the secondary veins generally very open, though variable in their direction; curve near, and along the borders, forming a more or less distinct narrow margin. The areolation distinct only at one place, where the epidermis is destroyed, is in small angular generally square areolæ. The deformed shape of this leaf, its border, its thick texture, and nervation, indicate its relation to this genus.

HABITAT.—Same as *Dryophyllum salicifolium*, in connection with coal strata of Southwest Colorado, at a higher stage of the Cretaceous, *H. Holmes.*

These two last-named species have no relation known as yet with any of the Dakota group, and none also with species of the Lower Lignitic or Eocene. Their affinity appears to be with a group of plants known from specimens of the upper stage of the Cretaceous of New Jersey. Indeed, the two horizons where fossil leaves have been found in this State, represent, by the lithological composition of the strata, their relative distance, and the characters of their fossil leaves, a striking affinity with what is seen in the stratification, the composition, and the plants of the formation referred above and reported by Mr. Holmes. The Lower Cretaceous of New Jersey is composed, as far as I could judge from the specimens which I examined, of sandy, white, or reddish coarse shale, wherein the plants are imbedded in profusion, but in a poor state of preservation. These represent many species identical with those of the Dakota group, or at least evidently related forms. Both *Magnolia Capellini* and especially *Magnolia alternans*, are among them. The upper group, on the contrary, has scarcely any identical species with those of the lower, though the intervening space is not more than one hundred feet; its types appear generally different, and as the vegetable remains are found in a soft clay, the leaves are far better preserved. Among the species of this Upper Cretaceous group, one is apparently closely related to the *Dryophyllum* described from Mr. Holmes's specimens.*

FRANGULACEÆ.

PALIURUS MEMBRANACEUS, Lesqx., Cret. Flora, p. 108, Pl. XX, fig. 6.

Leaf small, membranaceous, oval, obtuse, entire, palmately three-nerved from the base; lateral veins thin; nervilles distinct, in right angle to the veins and joining them.

RHAMNUS TENAX, Lesqx., Cret. Flora, p. 109, Pl. XXI, fig. 4.

Leaf entire, lanceolate-pointed or acuminate, narrowed by a curve to a short petiole; lateral veins close, numerous, thin, parallel, camptodrome.

TEREBINTHACEÆ.

JUGLANS? DEBEYANA, Heer, Cret. Flora, p. 110, Pl. XXIII, figs. 1–5.

Leaves coriaceous, entire, broadly ovate, obtuse, or with a short obtuse point, rounded-subcordate at the base, or narrowed by a curve and slightly decurring to the petiole; middle nerve thick; secondary veins numerous, open, camptodrome.

It has been remarked, in the introduction, that these leaves may be referable to *Rhus*. Count Saporta remarks that if there is among these leaves a proportionate number of them with unequilateral base, like figs. 4 and 5, they may indeed represent a *Juglans* or a *Juglandites*.

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* These specimens were received after my return from New Jersey, where, by the kindness of Dr. G. H. Cook, the director of the geological survey of that State, I had the privilege of examining the numerous materials of the State collection. I have not had yet opportunity of comparing the specimens of Colorado with those of New Jersey, and speak therefore from memory.

PHYLLITES RHOIFOLIUS, Lesqx., Cret. Flor., p. 111, Pl. XXII, figs 5 and 6.

Leaves coriaceous, lanceolate penninerve, irregularly obtusely dentate; middle nerve thick; secondary veins parallel, camptodrome, deeply marked.

PRUNUS? CRETACEUS, Lesqx., Cret. Flora, p. 111, Pl. XXIII, figs. 8 and 9;— Pl. IV, fig. 9.

Drupe ovate, obtusely pointed, grooved on one side to the middle, notched at the enlarged obtuse base.

Nothing new has been elicited in regard to the relation of this fruit, though another specimen has been found apparently representing the same species. As seen in fig. 9 of Pl. IV, it is exactly of the same size and form as the one in Pl. XXIII, fig. 8, of the Cret. Flora. It is upon the surface of a large flat fragment of sandstone, where it is imbedded to the middle of its thickness, the part figured being very distinct. From the remnants of a thin coat of matter similar to a shelly envelope, it seems to have been surrounded by a coriaceous pericarp. The same specimen represent a leaf of *Aralia Towneri.*

HABITAT.—South of Clay Center, Kansas, *H. C. Towner.*

INCERTÆ SEDIS.

ASPIDIOPHYLLUM, Lesqx.

Leaves large, triangular in outline, palmately trilobed, truncate and auricled at base; nervation coarse, primary nerves three from above the peltate top of the petiole; secondary veins close, parallel, camptodrome or craspedodrome.

The essential difference separating the leaves of this new division from those of *Sassafras* (*Araliopsis*) is the broadly peltate and auricled base. As seen from Plate II, fig. 1, the lateral veins are very open, nearly at a right angle with the middle one, and therefore the lobes have the same direction, and the leaf has nearly the appearance of a cross; these short broad lobes, either obtusely dentate by the extension of the point of the secondary veins entering them, or entire whenever these veins curve along them, are remarkably similar to those of *S. Harkerianum.* The secondary nervation, however, is of a somewhat different character, the veins being more curved in passing up to the borders, and also at a more obtuse angle of divergence. The rounded, more or less elongated auricle is nerved by the downward continuity of the secondary veins, or, as seen in fig. 2, by two pairs of secondary veins in right angle to the middle nerve, and two pairs of marginal veinlets from the top of the petiole. This disposition has analogy to the basilar nervation of *Credneria* leaves; with the difference, however, that in *Credneria* all the lower secondary veins are at a right angle to the midrib. The same kind of affinity is still more marked with species of *Protophyllum*, as for example *P. multinerve*, Cret. Flor., Pl. XVIII, fig. 1, whose leaves, however, are not lobed, and whose upper nervation is of an entirely different type. We have therefore still in these leaves a union of different characters separately and distinctly recognized in other groups of this remarkable flora.

ASPIDIOPHYLLUM TRILOBATUM, sp. nov. Pl. II, figs. 1, 2.

Leaves large, coriaceous, triangular or rhomboidal in outline, more or less deeply trilobate, broadly cuneate to the base, enlarged into an half-round auricle, three-nerved from above the peltate base of the thick middle nerve.

These leaves vary in size from ten to twenty-four centimeters long and

from twelve to thirty centimeters broad between the points of the lateral lobes; these are turned upward in the normal form, the angle of divergence of the lateral veins being 40° to 50°, with a very deep coarse nervation. The borders of the lobes are more generally dentate, and the veins, therefore, mostly craspedodrome.

I was disposed to consider as a separate species the leaf represented, fig. 1, greatly differing by its diminutive size, the direction of the lobes, and the still broader nervation. These leaves, of which we have two specimens, have the surface runcinate, or appearing as if they were not fully unfolded; they represent probably a peculiar form or variety of the same species, for, except this difference, the characters are the same.

HABITAT.—South of Fort Harker, Kansas, *Chs. Sternberg.*

PROTOPHYLLUM STERNBERGII, Lesqx., Cret. Flora, p. 101, Pl. XVI; Pl. XVIII, fig. 2.

Leaves large, coriaceous, peltate entire, rounded or cordate at base, gradually narrowed up into a slightly obtuse point; basilar veins one or two pairs.

PROTOPHYLLUM LECONTEANUM, Lesqx., Cret. Flora, p. 103, Pl. XVII, fig. 4; Pl. XVI, fig. 1.

Leaves coriaceous, round, more enlarged in the middle, entire; middle nerve thick, lowest secondary veins much divided, basilar veins in right angle to the middle nerve proportionally thick.

PROTOPHYLLUM ? NEBRASCENSE, Lesqx., Cret. Flora, p. 103, Pl. XXVII, fig. 3.

Leaf small, subcoriaceous, oval-oblong, abruptly narrowed to the petiole; borders entire, middle nerve thin, secondary veins close, parallel, all under the same angle of divergence.

This leaf is by its character referable to the generic division of the *Hamamelites*, and clearly related to the leaf of our Pl. VII, fig. 4.

PROTOPHYLLUM QUADRATUM, Lesqx., Cret. Flora, p. 104, Pl. XIX, fig. 1.

Leaves thickish, subcoriaceous, round-square in outline; truncate at the base and subpeltate, deeply undulate, obtuse; nervation thick, secondary veins straight to the borders.

PROTOPHYLLUM MINUS, Lesqx., Cret. Flora, p. 104, Pl. XIX, fig. 2; Pl. XXVII, fig. 1;— Pl. V, fig. 6.

Leaves small, coriaceous, broadly ovate, truncate or subcordate at the base; entire or slightly undulate, subpeltate.

These different forms of *Protophyllum* are clearly defined and preserve their characters in the numerous specimens which I have had for examination. Pl. IV, fig. 6, shows a very small leaf of this species, representing in miniature the large forms described in the Cret. Flora.

PROTOPHYLLUM MULTINERVE, Lesqx., Cret. Flora, p. 105, Pl. XVIII, fig. 1.

Leaves of medium size, coriaceous, oval-oblong, round-truncate at the base, peltate, middle nerve thick, secondary veins close, numerous, in an open angle of divergence, the lower ones in right angle and deflecting downward, borders entire or undulate.

PROTOPHYLLUM RUGOSUM, Lesqx., Cret. Flora, p. 105, Pl. XVII, figs. 1 and 2; Pl. XIX, fig. 3.

Leaves deltoid-ovate, rounded and subpeltate at the base, borders entire; nervation coarse, surface rugose, secondary veins irregular in distance and direction.

PROTOPHYLLUM HAYDENII, Lesqx., Cret. Flora, p. 106, Pl. XVII, fig. 3.

Leaves small, coriaceous, smooth, oblong-ovate, pointed, deeply irregularly undulate-lobed, abruptly rounded to the base, subpalmately three-nerved; secondary veins parallel, straight to the borders, basilar veins two or three pairs at right angles to the middle nerve.

The basilar nervation of this species, as also of the following, is of the *Credneria* type.

PROTOPHYLLUM CREDNERIOIDES, sp. nova. Pl. III, fig. 1; Pl. VIII, fig. 4.

Leaves small, nearly round, truncate at the base, long petioled; borders entire, undulate; nervation obscurely trifid; secondary veins on various angles of divergence.

These leaves, of which we have many specimens, vary in size from six to eight centimeters, and are as broad as long; they are more or less deeply undulate, but the borders are entire, though all the veins and their divisions pass to the borders; the petiole is comparatively long and slender and the secondary veins more or less open, according to their position, being at a right angle to the middle nerve near the base and at an acute angle of divergence near the top. As in the former species, the leaves are obscurely tripalmately-nerved, the lower lateral primary veins above the borders being underlaid as in *Credneria* by two pairs of thinner veins in right angle. In this case, however, as these lower veins branch, and have the same direction as those above, they are rather secondary veins, like the others, and the nervation should be considered as pinnate.

HABITAT.—Mostly found near Fort Harker, Kansas, *Chs. Sternberg.*

PROTOPHYLLUM? MUDGEI, Lesqx., Cret. Flora, p, 106, Pl. XVIII, fig. 3.

Leaf thick, coriaceous, ovate-obtuse, enlarged and truncate at base, equally denticulate; middle nerve very thick; secondary veins alternate, more or less branching, craspedodrome.

The leaf, the only fragment of which is figured, is of uncertain reference.

ANISOPHYLLUM SEMI-ALATUM, Lesqx., Cret. Flora, p. 98, Pl. VI, figs. 1–5.

Leaves thick, coarsely veined, ovate or obovate in outline, either abruptly narrowed, subtruncate and subcordate to the petiole, or rounded wedge-form to the base, irregularly lobate on one side, deeply undulate on the borders; nervation irregularly three to five palmate from above the base of the leaves; primary veins much divided.

EREMOPHYLLUM FIMBRIATUM, Lesqx., Cret. Flora, p. 107, Pl. VIII, fig. 1.

Leaf peltate, kidney-shaped, with an entire broadly truncate base; borders dentate by equal hastate or auricled, and pointed teeth; nervation seven-palmate.

VEGETABLE ORGANISMS OF UNCERTAIN AFFINITY.

PHYLLITES BETULÆFOLIUS, Lesqx., Cret. Flora, p. 112, Pl. XXVIII, figs. 4, 7.

Leaves small, mostly in fragments, round-ovate, truncate at the top, narrowed to the base by a round curve; borders dentate; nervation pinnate, irregular, craspedodrome.

PHYLLITES RHOMBOIDEUS, Lesqx., Cret. Flora, p. 112, Pl. VI, fig. 8.

Leaf rhomboidal, broadly cuneate to the base, more obtusely narrowed and undulate from the middle to an obtuse short point; nervation five-palmate from the base, the two inner lateral veins curving up at a very acute angle of divergence and acrodrome or nearly reaching the point of the leaf, branching outside, the external veins following the borders up to the middle of the leaf, where they anastomose with branches of the first pair.

PHYLLITES COTINUS, Lesqx.

BUMELIA MARCOUANA, Heer (Lesqx.), Cret. Flora, p. 90, Pl. XXVIII, fig. 2.

Leaf membranaceous, broadly oval, entire, emarginate, rounded downward to a long slender petiole, penninerve.

From information received of Professor Heer, this leaf positively differs from the one which he examined and which is figured in Dana's Manual of Geology. Though the likeness of this leaf to those of *Rhus cotinus* is marked, its relation is not definite.

PHYLLITES VANONÆ, Heer,—Cret. Flora, p. 113, Pl. XX, fig. 7; Pl. XXVIII, fig. 8.

Leaves small, ovate-lanceolate, pointed, cuneiform to the base; borders entire, middle nerve thin, secondary veins few, scattered, camptodrome.

PHYLLITES UMBONATUS, Lesqx., Cret. Flora, p. 113, Pl. XIX, fig. 4.

Leaf quadrate in outline, truncate at the base, deeply notched at the top by the splitting of the thick middle nerve, irregularly broadly undulate on the borders; secondary veins few, at irregular distances, nearly at right angle to the middle nerve, camptodrome.

PHYLLITES AMORPHUS, Lesqx., Cret. Flora, p. 113, Pl. XXII, figs. 3, 4.

Two fragments of coriaceous, obovate, entire leaves, narrowed to the base (broken); middle nerve deep and narrow; secondary veins either in right angle to the middle nerve or curved downward, or passing up in an acute angle of divergence, branching and anastomosing in varions abnormal ways.

PTENOSTROBUS NEBRASCENSIS, Lesqx., Cret. Flora, p. 114, Pl. XXIV, fig. 1.

Cone oblong, cut in its length; seeds oblong-oval, lenticular, obtuse at one end, pointed at the other, winged, wings oval oblong, striated.

CAULINITES SPINOSA, Lesqx., Cret. Flora, p. 115.

Stems or branches cylindrical, with rough surface marked by irregular, close dots, or small cavities resembling the impressions of scale; bearing long spines at right angles.

CARPOLITHES ?, Cret. Flora, p. 114, Pl. XXVI, fig. 5, Pl. XXX, fig. 11.

Fruit ? large, oval-pointed at both ends, costate, marked at the lower end by a small hollow surrounded by small semi-globular bolsters corresponding with the end of the costæ.

The bodies represented by the figures are doubtfully referred to some vegetable organism.

It would, perhaps, seem advisable to close this review by a table of comparison, exposing the relation of the species of the Dakota group with those of the Cretaceous floras of other countries. A table of this kind, however, would not offer any valuable information, and could be of little interest, on account of the scantiness of the materials available for comparison. The few points of affinity between our American Cre-

taceous plants and those of Europe have been remarked in the Cretaceous Flora, and, since its publication, no other work has appeared on the same subject but the third volume of the Arctic Flora, where, as remarked before, Professor Heer describes the species of fossil plants from two stages of the Cretaceous of Greenland; a lower one, that of Come; an upper one, that of Atane, and an intermediate small group from Spitzberg. With the species of the first division, the Dakota group flora has *Gleichenia nordenskiöldi*, identical and none related; with those of the second, it has two Conifers—*Sequoia fastigiata* and *Pinus Quenstedti*. This last has been described also by the author, from Spitzberg, and formerly from Moletin. In the monocotyledonous, our *Phragmites cretaceous* seems identical with *Arundo greenlandica*, Heer, of the same upper stage, and in the dicotyledonous, *Myrica cretacea*, Lesqx., is comparable to *M. zenkeri*, Heer, which is represented by a fragment only. There is still an evident relation of the leaves described by Heer as *Chondrophyllum orbiculatum* and *C. nordenskiöldi* with those of *Hedera ovalis*, of the Dakota group. We have also *Andromeda Parlatorii*, *Magnolia Capellini*, and *M. alternans* present in both floras. These three species are apparently extensively distributed in the Cretaceous.

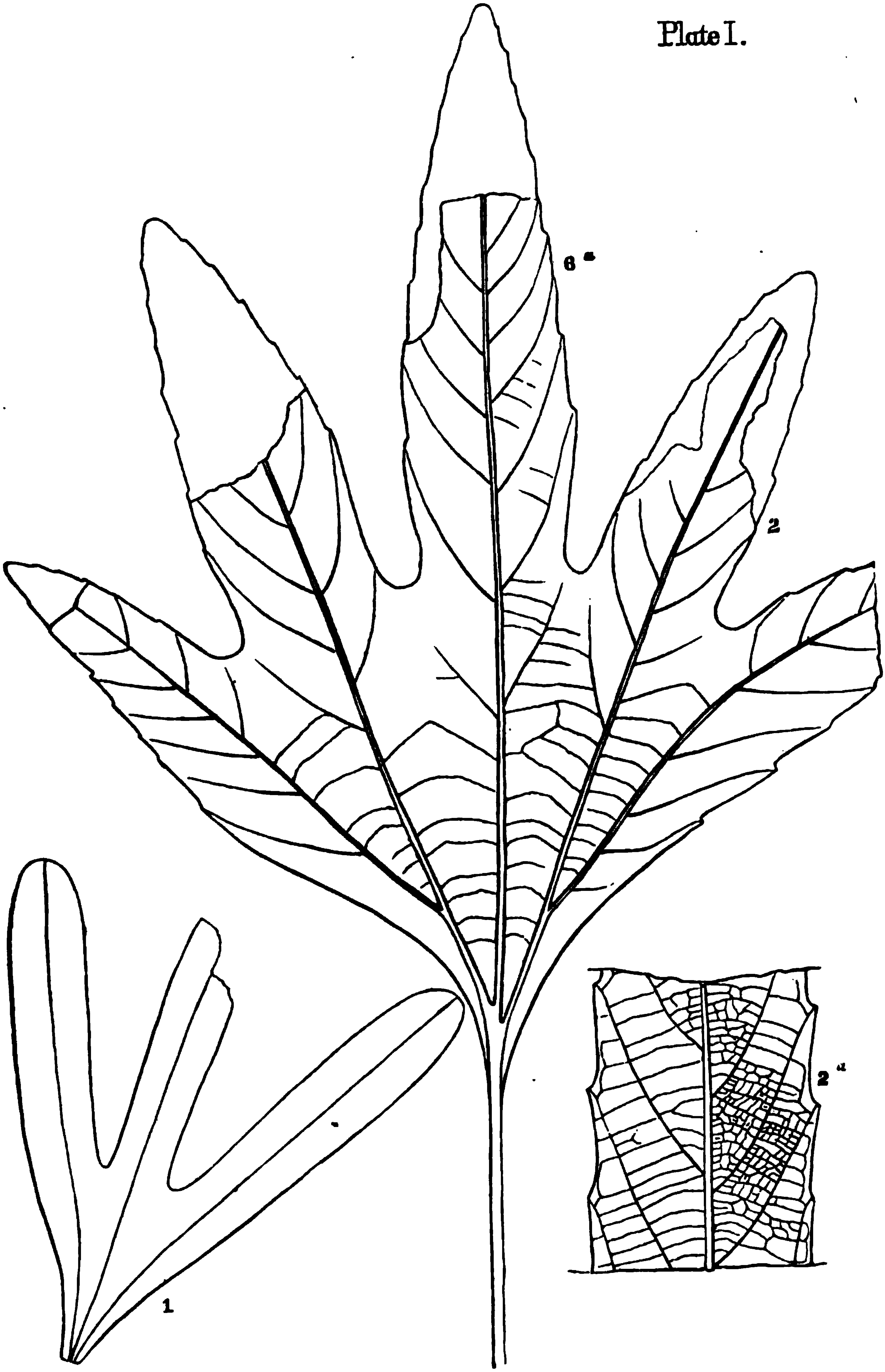
Without taking into account the more or less acceptable modifications of generic and specific forms proposed in this review, we have here an addition to the North American Cretaceous flora of twenty-four species, mostly clearly defined from very fine specimens. This contribution, the result of the discoveries made during one year only, by two zealous young naturalists who have explored merely an area of small extent in the counties where they live, shows what abundant materials are still left in the strata of the Dakota group to reward future researches. It exposes, also, with more evidence the riches and the diversity of the vegetation of the Cretaceous period, manifested as it is by the distribution of the dicotyledonous leaves in the three great divisions of this class of plants; by the numerous, clearly-limited, generic groups which they represent, as well as by the multiplicity of specific forms referable to some of the genera. The species of *Menispermites* and of *Protophyllum*, for example, are as distinctly separated by the characters of their leaves, though preserving the unity of their generic type, as we see them at the present time under analogous climatic circumstances.

These facts tend to confirm the general conclusions briefly exposed in the Cretaceous Flora concerning the origin and the distribution of the dicotyledonous species, a question to which the history of our present North American flora is interested in the highest degree.

EXPLANATION OF PLATE I.

Fig. 1. ARALIA TRIPARTITA, *sp. nov.*, page 348.
Fig 2, 2[a], ARALIA SAPORTANEA, *sp. nov.*, page 350.

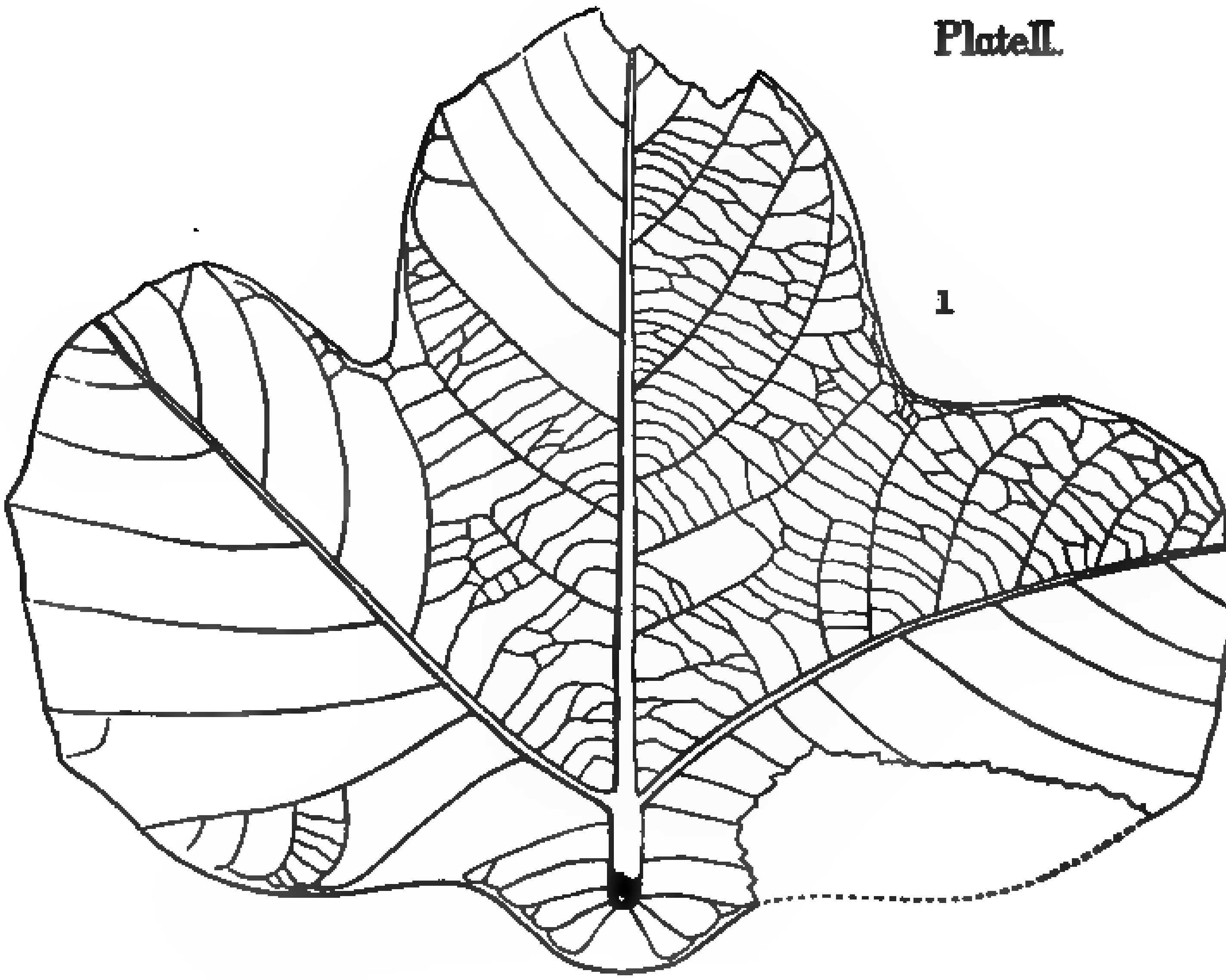
Plate I.



EXPLANATION OF PLATE II.

Figs. 1, 2. ASPIDIOPHYLLUM TRILOBATUM, *sp. nov.*, page 361.
Fig. 3. AMPELOPHYLLUM ATTENUATUM, *sp. nov.*, page 354.
Fig. 4. PHYLLOCLADUS SUBINTEGRIFOLIUS, *Lesqx.*, page 337.
Figs. 5, 5a. GLEICHENIA NORDENSKIÖLDI, *Heer.*, page 334.

Plate II.



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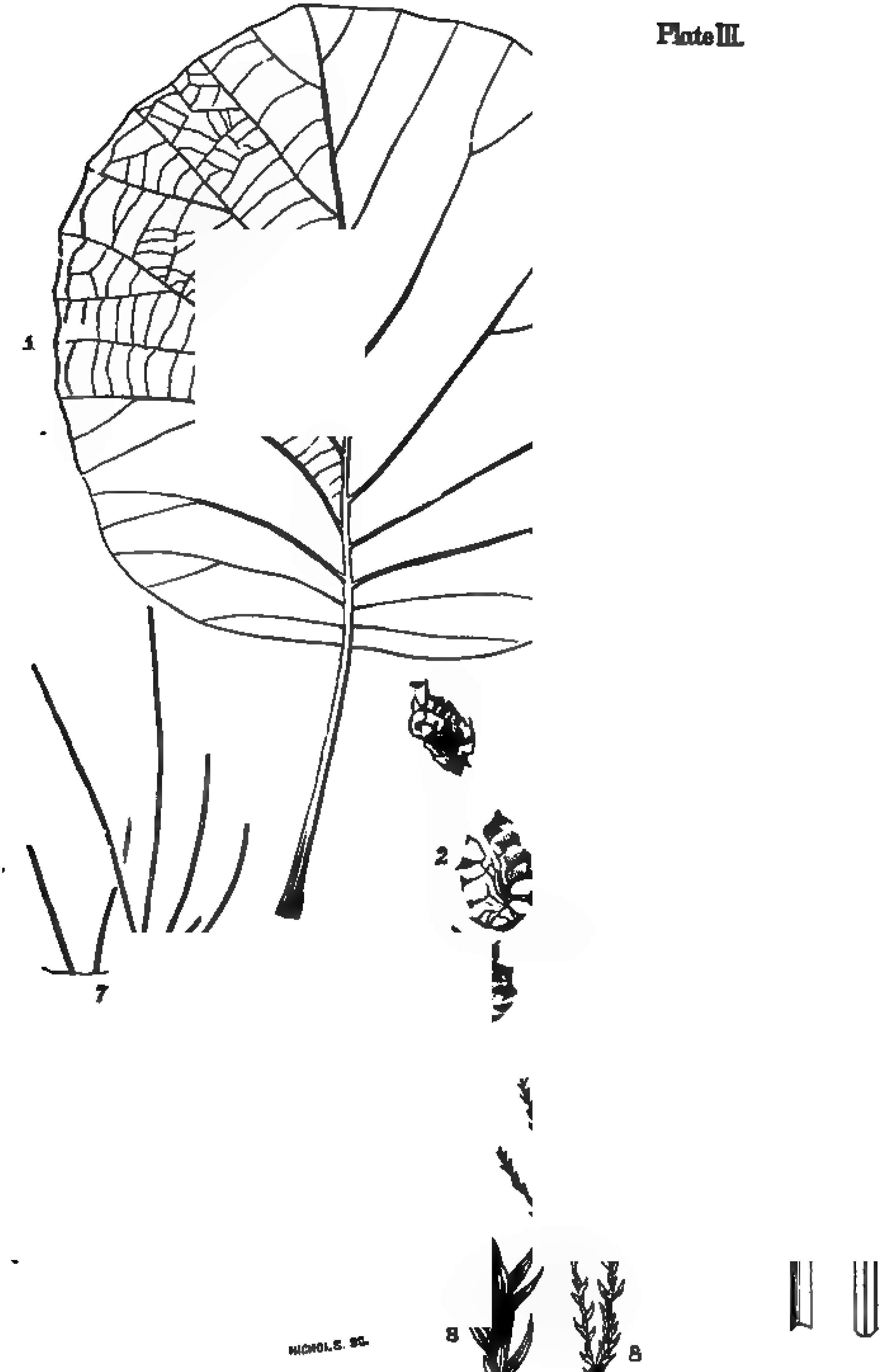
EXPLANATION OF PLATE III.

Fig. 1. PROTOPHYLLUM CREDNERIOIDES, *sp. nov.*, page 363.
Figs. 2, 8, 8ª. SEQUOIA FASTIGIATA, *Sternb.*, page 335.
Fig. 3. HEDERA PLATANOIDEA, *sp. nov.*, page 351.
Fig. 4. MYRICA CRETACEA, *sp. nov.*, page 339.
Fig. 5. ANDROMEDA AFFINIS, *sp. nov.*, page 348.
Figs. 6, 6ª, 7, 7ª. PINUS QUENSTEDTI, *Heer.*, page 336.

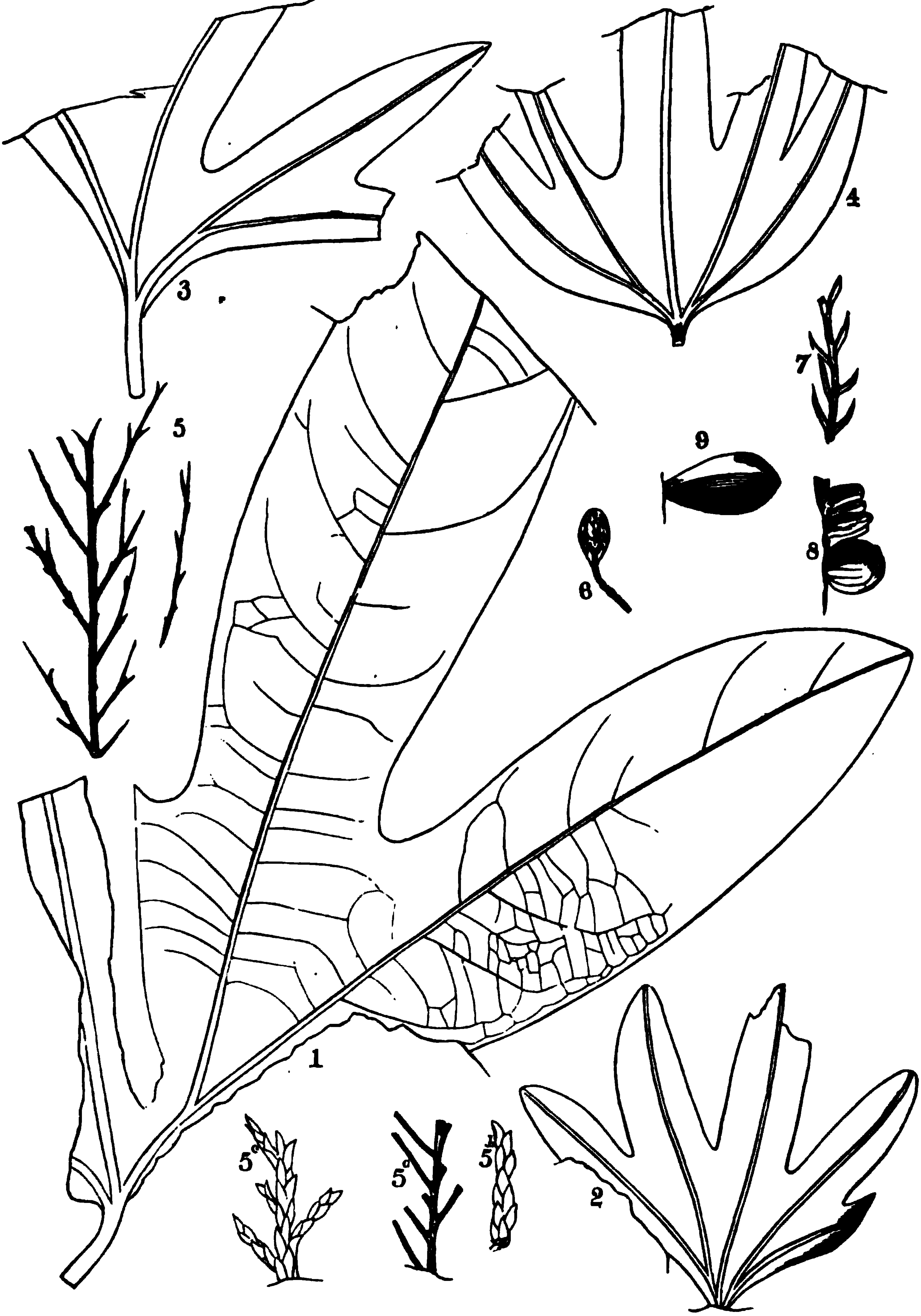
Plate III.



EXPLANATION OF PLATE IV.

Fig. 1. ARALIA TOWNERI, *sp. nov.*, page 349.
Figs. 2–4. ARALIA CONCRETA, *sp. nov.*, page 349.
Figs. 5–7. SEQUOIA CONDITA, *sp. nov.*, page 335.
Fig. 8. INOLEPIS ?, *species.*, page 337.
Fig. 9. PRUNUS ? CRETACEA, *Lesqx.*, page 361.

Plate IV.



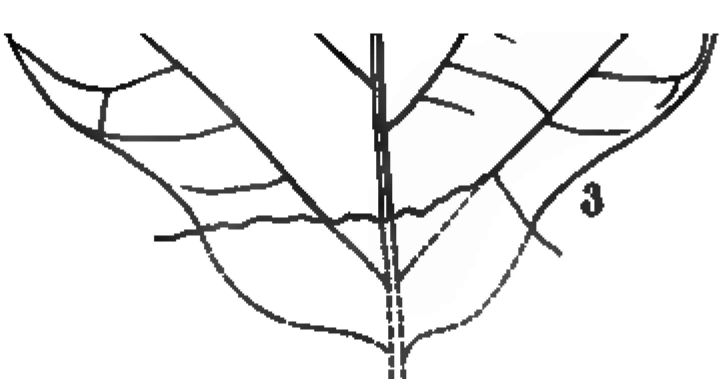
EXPLANATION OF PLATE V.

Figs. 1 and 2. LAURUS PROTEÆFOLIA, *sp. nov.*, page 342.
Fig. 3. MENISPERMITES POPULIFOLIUS, *sp. nov.*, page 357.
Fig. 4. MENISPERMITES OVALIS, *sp. nov.*, page 357.
Fig. 5. FICUS DISTORTA, *sp. nov.*, page 342.
Fig. 6. PROTOPHYLLUM MINUS, *Lesqx.*, page 362.
Fig. 7. FICUS LAUROPHYLLUM, *Lesqx.*, page 342.

Pl. 18 V.

EXPLANATION OF PLATE VI.

Fig. 1. DRYOPHYLLUM (QUERCUS) LATIFOLIUM, *sp. nov.*, page 340.
Fig. 2. LOMATIA SAPORTANEA. *Lesqx.* An enlarged leaflet, page 346.
Fig. 3. CISSITES HEERII, *sp. nov.*, page 353.
Fig. 4. MENISPERMITES CYCLOPHYLLUS, *sp. nov.*, page 358.



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EXPLANATION OF PLATE VII.

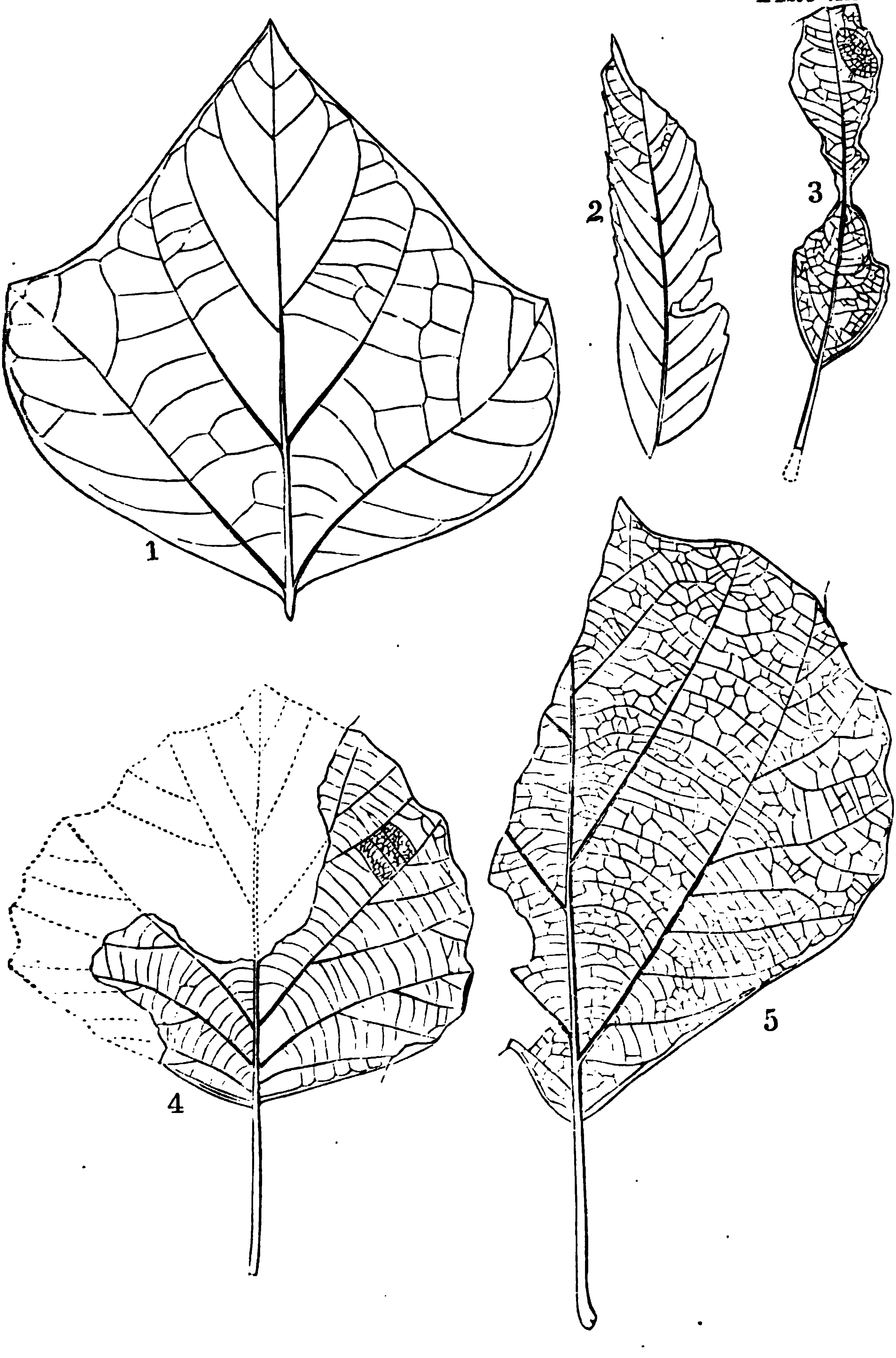
Figs. 1 and 2. CISSITES HARKERIANUS, *Lesqx.*, page 352.
Fig. 3. MENISPERMITES OBTUSILOBA, *Lesqx.*, page 356.
Fig. 4. HAMAMELITES KANSASEANA, *Lesqx.*, page 355.
Fig. 5. HEDERA SCHIMPERI, *sp. nov.*, page 351.

Plate VII.

EXPLANATION OF PLATE VIII.

Fig 1. CISSITES ACUMINATUS, *sp. nov.*, page 353.
Fig. 2. DRYOPHYLLUM (QUERCUS) SALICIFOLIUM, *sp. nov.*, page 340.
Fig. 3. ILEX STRANGULATA, *sp. nov.*, page 359.
Fig. 4. PROTOPHYLLUM CREDNERIOIDES, *sp. nov.*, page 363.
Fig. 5. PLATANUS HEERII, *Lesqx.*, page 341.

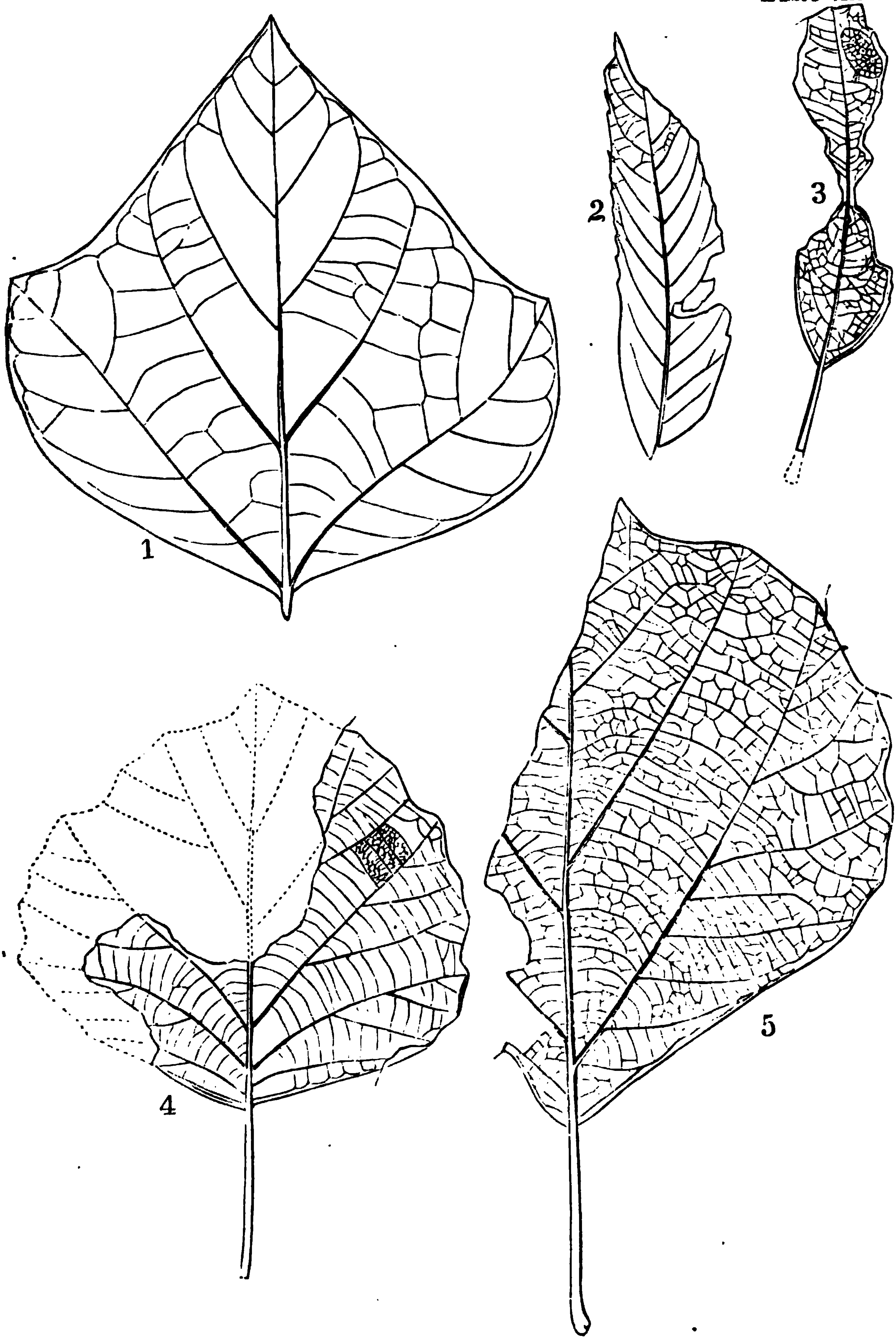
Plate VIII



EXPLANATION OF PLATE VIII.

Fig 1. CISSITES ACUMINATUS, *sp. nov.*, page 353.
Fig. 2. DRYOPHYLLUM (QUERCUS) SALICIFOLIUM, *sp. nov.*, page 340.
Fig. 3. ILEX STRANGULATA, *sp. nov.*, page 359.
Fig. 4. PROTOPHYLLUM CREDNERIOIDES, *sp. nov.*, page 363.
Fig. 5. PLATANUS HEERII, *Lesqx.*, page 341.

Plate VIII



REPORT OF W. H. JACKSON.

Plate I.

ANCIENT RUINS IN SOUTHWESTERN COLORADO.

By W. H. Jackson.

In the extreme southwestern corner of Colorado Territory, west of the one hundred and eighth degree of longitude, are groups of old ruined houses and towns, displaying a civilization and intelligence far beyond that of any of the present inhabitants of this or adjacent Territory.

We will endeavor, in the few pages following, to describe these with as much minuteness and circumspection as a very hasty trip enabled us to observe; depending more upon the pictorial illustrations accompanying this article for clear exposition of the subject than upon any choice of words.

Although ruins in considerable number and importance were said to exist along the Rio Las Animas and San Juan, we did not think it best to spare any of the little time at our disposal for their investigation. Our object being to find those in which the picturesque predominated and were the least known, we directed our course to the westward, having obtained reliable information of the existence of some which would come up to our anticipations. The Rio Mancos, one of the western tributaries of the San Juan, rises in two principal forks among the western foot-hills of the Sierra La Plata, flows southwesterly through fertile and beautiful valleys to a great table-land, known as the "Mesa Verde," and entering, flows directly south through it to the valley of the San Juan, and then turning west again joins that stream near the crossing of the boundary-lines of the four Territories.

Commencing our observations in the park-like valley of the Mancos between the *mesa* and the mountains, we find that the low benches which border the stream upon either side bear faint vestiges of having, at some far-away time, been covered with dwellings, grouped in communities apparently, but now so indistinct as to present to the eye little more than unintelligible mounds. By a little careful investigation, however, the foundations of great square blocks, of single buildings, and of circular inclosures, can be made out; the latter generally with a depressed center, showing an excavation for some purpose. The greater portion of these mounds are now overgrown with artemisia, piñon-pine, and cedar, concealing them almost entirely from casual observation. We found the surest indication of their proximity in the great quantity of broken pottery, which covered the ground in their neighborhood, the same curiously indented, painted, and glazed ware found throughout New Mexico and Arizona. It was all broken into very small pieces, none that we could find being larger than a silver dollar. We had no opportunity to make any excavations about these old mounds; but such little scratching around as we could do developed nothing new below the surface, all the pottery which covers the ground having been broken and scattered since the demolition of the homes of the makers. Nowhere among these open-plains habitations could we discover any vestiges of stone-work, either in building material or implements. It is

very evident that the houses were all of adobe, the mound-like character of the remains justifying that belief.

The "Mesa Verde" extends north and south about twenty, and east and west about forty miles. It is of a grayish-yellow Cretaceous sandstone, with a very nearly horizontal bedding, so that the escarpment is about equal upon all sides, ranging from 600 to 1,000 feet in height. The capping or upper strata are generally firmly and solidly bedded, retaining a perpendicular face of about 200 feet, with a succession of benches below, connected by the steep slopes of the talus. Side-cañons penetrate the *mesa*, and ramify it in every direction, always presenting a perpendicular face, so that it is only at very rare intervals that the top can be reached; but, once up there, we find excellent grazing, and thick groves of cedar and piñon-pine. From the bottom of the cañon up, the slopes of the escarpment are thickly covered with groves of cedar and piñon, gnarled and dwarfed, but sucking up a vigorous livelihood from the cracks and crevices of the barren declivities. Below, the cottonwood and willow grow luxuriantly beside the streams, while dense growths of a reedy grass tower above our heads as we ride through it. Throughout its entire length, the cañon preserves an average width of about 200 yards, sometimes much wider and again narrower. The stream, meandering from side to side, frequently interrupted by beaver-dams, cuts a deep channel in the friable earth which characterizes all the valley-lands of this region, while the banks upon either one side or the other are perpendicular, so that it is an extremely troublesome matter to cross. Added to the difficulties of getting in and out of the stream is a thick-matted jungle of undergrowth, tall, reedy grass, willows, and thorny bushes, all interlaced and entwined by tough and wiry grape-vines bordering its banks upon either one side or the other. The current is sluggish, and the water tinged with a milky translucency, gathered from the soil.

Entering the cañon at its upper end, we strike into the old Indian trail which comes over from the head of the Rio Dolores, and, passing down this cañon a short distance, turns off to the left and goes over to the La Plata. About a hundred Indians had just passed over it with their horses and goats, so that it was in most excellent traveling order, although winding in and out, and over and among great blocks of sandstone and other *débris* from above; the encroaching stream, too, frequently forcing the narrow pathway high up on the slopes of the projecting spurs, the treacherous character of the banks of the stream forbidding the crossing and recrossing usual in such cases. Grouped along in clusters, and singly, were indications of former habitations, very nearly obliterated, and consisting mostly, in the first four or five miles, of the same mound-like forms noticed above, and accompanied always by the scattered, broken pottery. Among them we found one building of squared and carefully-laid sandstone; one face only exposed, of three or four courses, above the mass of *débris*, which covered everything. This building lay within a few yards of the banks of the stream; was apparently about 10 feet by 8, the usual size, as near as we could determine, of nearly all the separate rooms or houses in the larger blocks, none larger, and many not more than 5 feet square. The stones exposed are each about 7 by 12 inches square and 4 inches thick, those in their original position retaining correct angles, but, when thrown down, worn away, and rounded by attrition to shapeless bowlders. Being so exposed to the elements, the cementing material which bound the masonry together is entirely worn away upon the surface; but, upon pulling away a few courses, it was found binding the rocks together quite

Plate II

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Plate III.

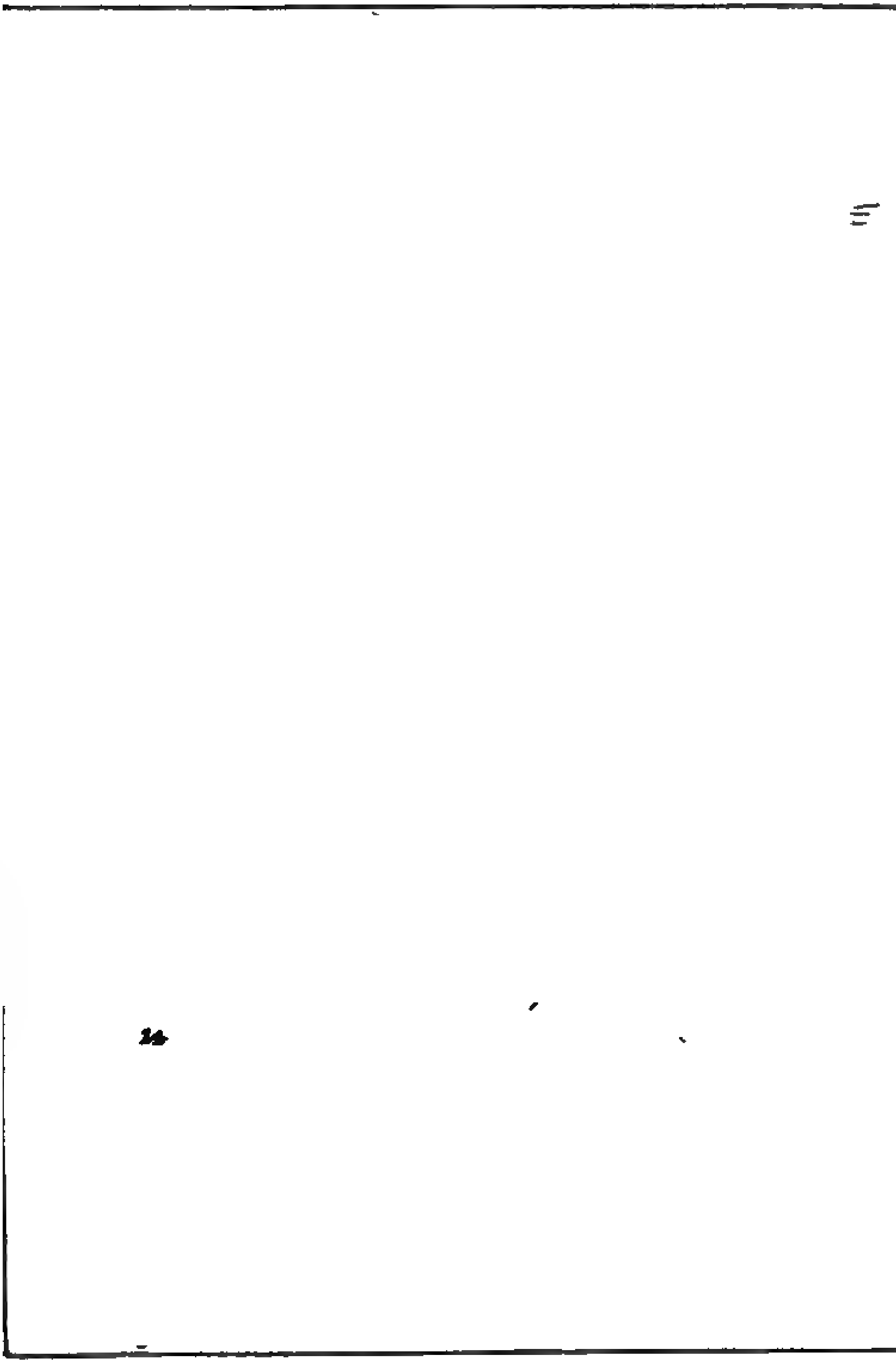

Plate III.

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firmly. It was not, however, anything more than an adobe or clay-cement.

As we progressed down the cañon, the same general characteristics held good; the great majority of the ruins consisting of heaps of *débris*, a central mass considerably higher and more massive than the surrounding lines of subdivided squares. Small buildings, not more than 8 feet square, were often found standing alone apparently; no trace of any other being detected in their immediate neighborhood.

We now commenced to note another peculiar feature. Upon our right, the long slopes of protruding strata and *débris* formed promontories, extending out into the cañon. Upon these, and not more than 50 feet above the stream, we found frequent indications of their having been occupied by some sort of works, the foundations of which in every case were circular, with a deep depression in the center, and generally occurring in pairs, two side by side, ranging from 10 to 20 feet in diameter. There was no masonry of any kind visible, but thickly strewn all about any quantity of broken pottery. Above, were indications of habitations in the face of the cliff, but not marked enough to warrant further search.

At those places where the trail ran high up, near the more precipitous portion of the bluff, we found remnants of stone walls, inclosing spaces of from 5 to 12 feet in length, in the cave-like crevices running along the seams. They were pretty well demolished, the stones undressed and imbedded in mud mortar. In many places, little niches or crevices in rock had been walled up into cupboard-like inclosures of about the size of a bushel-basket. We searched them eagerly, but they had all been despoiled before us. Nothing of any greater importance was found up to the time we made camp at night-fall. All that we had seen during the day was of exceeding interest, but came far short of our expectations.

Our camp for the night was among the stunted piñons and cedars immediately at the foot of the escarpment of the *mesa;* its steep slopes and perpendicular faces rising nearly 1,000 feet above us. Quantities of broken pottery were strewn across the trail, to the edge of the stream, and as ruins of some sort generally followed, close attention was paid to the surroundings; but, with the exception of a small square inclosure of rough slabs of stone, set in the earth endwise, and indicating, possibly, a grave, nothing was found to reward our search. Just as the sun was sinking behind the western walls of the cañon, one of the party descried far up the cliff what appeared to be a house, with a square wall, and apertures indicating two stories, but so far up that only the very sharpest eyes could define anything satisfactorily. We had no field-glass with the party, and to this fact is probably due the reason we had not seen others during the day in this same line; for there is no doubt that ruins exist throughout the entire length of the cañon, far above and out of the way of ordinary observation. Cedar and pines also grow thickly along the ledges upon which they are built, hiding completely anything behind them. All that we did find were built of the same materials as the cliffs themselves, with but few, and then only the smallest apertures toward the cañon; the surface being dressed very smooth, and showing no lines of masonry, it was only upon the very closest inspection that the house could be separated from the cliff.

The discovery of this one, so far above anything heretofore seen, inspired us immediately with the ambition to scale the height and explore it, although night was drawing on fast, and darkness would probably overtake us among the precipices, with a chance of being detained there all night. All hands started up, but only two persevered

to the end. The first 500 feet of ascent were over a long, steep slope of *débris*, overgrown with cedar; then came alternate perpendiculars and slopes. Immediately below the house was a nearly perpendicular ascent of 100 feet, that puzzled us for a while, and which we were only able to surmount by finding cracks and crevices into which fingers and toes could be inserted. From the little ledges occasionally found, and by stepping upon each other's shoulders, and grasping tufts of *yucca*, one would draw himself up to another shelf, and then, by letting down a stick of cedar, or a hand, would assist the other. Soon we reached a slope, smooth and steep, in which there had been cut a series of steps, now weathered away into a series of undulating hummocks, by which it was easy to ascend, and without them, almost an impossibility. Another short, steep slope, and we were under the ledge upon which was our house, (Fig. 12, Plate III.) It was getting quite dark, so we delayed no longer than to assure ourselves that it was all we hoped for, and to prospect a way up when we should return the next morning with the photographic outfit.

Bright and early, as soon as breakfast was dispatched, we commenced the ascent. Mexico, our little pack-mule, with the apparatus upon her back, by sharp tacks and lively scrambling over the rocks, was able to reach the foot of the precipice of which I have spoken above. Up this we hauled the boxes containing the camera and chemicals by the long ropes taken from the pack-saddle. One man was shoved up ahead, over the worst place, with the rope, and tying it to a tree, the others easily ascended.

The house stood upon a narrow ledge, which formed the floor, and was overhung by the rocks of the cliff. The depth of this ledge was about 10 by 20 in length, and the vertical space between ledge and overhanging rock some fifteen feet. The house occupied the left-hand half as we face it; the rest being reserved as a sort of esplanade, a small portion of the wall remaining which cut it off from the narrow ledge running beyond. The edges of the ledge upon which the house stood were rounded off, so that its outside wall had to be built upon an incline of about forty-five degrees; the esplanade, too, had been extended by three abutments, built out flush with the walls of the house, upon the steeply-inclined slope, and giving support probably to a balustrade.

The house itself, perched up in its little crevice like a swallow's nest, consisted of two stories, with a total height of about 12 feet, leaving a space of two or three feet between the top of the walls and the overhanging rock. We could not determine satisfactorily whether any other roof had ever existed or whether the walls ran up higher and joined the rock, but we incline to the first supposition. The ground-plan showed a front room about 6 by 9 feet in dimensions, and back of it two smaller ones, the face of the rock forming their back walls. These were each about 5 by 7 feet square. The left hand of the two back rooms projected beyond the front room in an L. The cedar beams, which had divided the house into two floors, were gone, with the exception of a few splintered pieces and ends remaining in the wall, just enough to show what they were made of. We had some little doubt as to whether the back rooms were divided in the same way, nothing remaining to prove the fact, excepting holes in the walls, at the same height as the beams in the other portion. In the lower front room are two apertures, one serving as a door, and opening out upon the esplanade, about 20 by 30 inches in size, the lower sill 24 inches from the floor; and the other a small outlook, about 12 inches square, up near the ceiling, and looking over the cañon beneath. In the upper story, a window corresponding in

size, shape, and position to the door below, commands an extended view down the cañon. The upper lintel of this window was of small, straight sticks of cedar, of about the size of one's finger, laid close together, the small stones of the masonry resting upon them. Directly opposite this window is a similar one, opening into a large reservoir, or cistern, the upper walls of which come nearly to the top of the window. This is semicircular, inclosing the angle formed by the side wall of the house against the rock, with an approximate capacity of about two and a half hogsheads. From the window, and extending down to the bottom of the reservoir, are a series of cedar pegs, about a foot apart, enabling the occupants to easily reach the bottom. The entire construction of this little human eyrie displays wonderful perseverance, ingenuity, and some taste. Perpendiculars were well regarded, and the angles carefully squared. The stones of the outer rooms or front were all squared and smoothly faced, but were not laid in regular courses, as they are not uniform in size, ranging from 15 inches in length and 8 in thickness down to very small ones. About the corners and the windows, considerable care and judgment were evident in the overlapping of the joints, so that all was held firmly together. The only sign of weakness is in the bulging outward of the front wall, produced by the giving way or removal of the floor-beams. The back portion is built of rough stone, firmly cemented together. The mortar is compact and hard, a grayish-white, resembling lime, but cracking all over. All the interstices between the larger stones were carefully chinked in with small chips of the same material. The partitions were of the same character as the smooth wall outside, both presenting somewhat the appearance of having been rubbed down smooth after they were laid. The apertures, from one room to another, are small, corresponding in size and position to those outside. Most peculiar, however, is the dressing of the walls of the upper and lower front rooms, both being plastered with a thin layer of firm adobe cement of about an eighth of an inch in thickness, and colored a deep maroon-red, with a dingy white band 8 inches in breadth, running around floor, sides, and ceiling. In some places it has peeled away, exposing a smoothly-dressed surface of rock. No signs of ornamentation, other than the band alluded to, were visible. The floor, which was covered to a depth of 2 or 3 inches with dust, dirt, and the excrement of small animals, had been evened up with a cement resembling that in the walls. The back rooms were half-filled with rocky *débris* from roof and cliff.

While busied with my negatives, the others had prospected the ledge in opposite directions, coming upon ample evidence of its having been quite thickly peopled. Ruins of half a dozen lesser houses were found near by, but all in such exposed situations as to be quite dilapidated. Some had been crushed by the overhanging wall falling upon them, and others had lost their foot-hold and tumbled down the precipice. One little house in particular, at the extremity of this ledge, about fifty rods below the one described above, was especially unique in the daring of its site, filling the mind with amazement at the temerity of the builders and the extremity to which they must have been pushed. Careful views of this having been secured so as to show as well as possible its almost complete inaccessibility, we felt impelled to hurry on to new developments. Apparatus was carefully lowered to the patiently-waiting mule, and adjusted to the pack-saddle, then, mounting our own animals, we pushed on down the cañon, which now opened out into quite a valley, side cañons opening in from either hand, adding much to the space. Every quarter-mile, at the most, we came upon evidences

of former habitations, similar to those already described; the greater majority occurring in the level bottoms and on the low spurs of the escarpment.

Two or three miles below the house in Fig. 12, we discovered a wall standing in the thick brush upon the opposite side of the river. Considerable difficulty was experienced in crossing; in some places having to cut our way through the entangling vines with our belt-knives, and then, when the bed of the stream was reached, had to follow it some distance before an opportunity occurred to emerge.

The walls before us were a portion of an old tower, (see Fig. 1, Plate ,) in the midst of a group of more dimly marked ruins or foundations, extending some distance in each direction from it. As seen in the figure referred to, the tower consists of two lines of walls, the space between them divided into apartments, with a single circular room in the center. The outside diameter of all is 25 feet, that of the inner circle 12* feet, and as the walls were respectively 18 and 12 inches in thickness, left a space of 4 feet for the small rooms. This outer circle was evidently divided into six equal apartments, but only the divisions marked in the diagram could be distinguished. In the places where they should have occurred, the walls are so broken down and covered with *débris* as to render all details indistinguishable. Where the walls are standing, they show small window-like doors opening into the inner circle. The highest portion of the inner wall is now not more than 8 feet, and of the outer about 15. From the amount of *débris*, it could not have been much higher—not more than 20 feet at the most. The space between the walls is filled with *débris*, while outside there is very little, except where the wall is totally ruined.

The stones of which this tower was constructed are irregular in size and shape, but with the outer face dressed to a uniform surface, and of the same average size as those already described. The mortar and "chinking" had been worn out entirely from the more exposed portions, giving the wall the appearance of having been dry-laid; but upon pulling away some of the stones to a little depth, they were found to have been well cemented.

Passing on down the cañon, not stopping now to notice the more ordinary forms of ruins, we passed the mouths of numerous side-cañons, down which come great freshets during the rainy season, gouging out deep arroyos, and strewing the surface with the collected *débris* of piñon and cedar, sage-brush and cacti. About the mouth of Coal Cañon, particularly, the whole surface of the "wash" was covered with lumps of fine-looking bituminous coal, as though a thousand coal-carts had traveled that way with their tail-boards out.

We camped at sunset at what our guide called the Rattlesnake Bend, within a half dozen miles of the outlet of the cañon. We had not discovered any more of the high cliff-houses during the day; but there is no doubt that, if we had had a good field-glass with us, many more might have been found along the crevices near the summit of the escarpment. To have verified our suppositions by a personal inspection would have involved a great deal of labor, and more time than we could have spared from our very scanty store. In the vicinity of our camp, the cañon changed much in appearance; instead of the long slope of talus capped

* These dimensions were estimated from the photograph after leaving the locality, not having the time or appliances for accurate measurement while there. The same ruin has since been examined by Mr. Holmes and accurately measured, with the following results: Diameter over all 43 feet; of the inner circle, 25 feet. Mr. Holmes also makes out ten apartments instead of six. Bulletin No. 1, vol. 2, p. 11.

Plate V.

by a perpendicular ledge, we have here a perpendicular ledge first, of 200 or 300 feet, and then a long receding bench, back to the higher *mesa* beyond.

Close to our camp was one of the little towers that occur quite frequently, about 10 feet in diameter, and now some 8 feet in height, with the inside half-filled with the *debris* from the walls. Half a mile below, in the vertical face of rock, and at a height of from 50 to 100 feet from the trail, were a number of little nest-like habitations. Fig. 5, Plate I, illustrates one of them, and their general character. Communication with the outside world was from above to a small window-like door, not showing in the sketch. Two small apertures furnish a lookout over the valley. The walls are as firm and solid as the rocks upon which they are built. The stones are more regular in size than any noticed heretofore, but smaller. The chinking-in of small chips of stone is noticeably neat and perfect on the inside. This is not a commodious dwelling; 15 feet would span its length, and 6 its height, while in depth it is not more than 5 feet. Near by, upon a low ledge, and readibly accessible from below, is a string of five or six houses, evidently communicating, mere kennels compared with some others, made by walling up the deep cave-like crevices in the sandstone. The same hands built them that lived in the better houses; the masonry being very similar, especially the inside chinking, which was perfect, and gave the walls a very neat appearance. Fig. 8 of Plate II is an example of the tenacity of the mortar; the view being of one of the line of little houses just spoken of. In this case, a portion of the ledge upon which the house stands has become separated from the cliff, carrying a portion of one of the buildings with it; and although torn away from the remaining wall, and thrown over at a considerable angle, yet it remains perfectly firm and unshaken.

Scratched into the face of the cliff which contains these houses are various inscriptions, one of which is depicted in Fig. 6 of Plate I. As they are not cut in very deeply, and in some places mere scratches, it is very doubtful whether they are contemporaneous with the houses themselves.

Two or three miles farther, and the cañon changes in feature again; the highest level of the *mesa* coming forward and towering over the valley with a thousand feet of altitude; the bottom-lands widening out to a half and three-quarters of a mile in breadth. Cottonwood and willow fringe the meandering stream in pleasant groves, while the dead level of the valley is heavily carpeted with a dense growth of artemisia and cacti. Everything is dry, dusty, and barren; the stream itself losing in volume, and becoming more turbid. Fig. 13 of Plate III represents in outline the characteristics of the cañon, or valley rather, at this point.

In the high bluff, on the right hand in the sketch, are some of the most curious and unique little habitations yet seen. While jogging along under this bluff, fully 1,000 feet in height, and admiring its bold outlines and brilliant coloring, one of our party, sharper-eyed than the rest, descried, away up near the top, perfect little houses, sandwiched in among the crevices of the horizontal strata of the rock of which the bluff was composed. While busy photographing, two of the party started up to scale the height, and inspect this lofty abode. By penetrating a side-cañon some little ways, a gradual slope was found, that carried them to the summit of the bluff. Now, the trouble was to get *down* to the house, and this was accomplished only by crawling along a ledge of about 20 inches in width, and not tall enough for more than a creeping position. In momentary peril of life, for the least mistake

would precipitate him down the whole of this dizzy height, our adventurous seeker after knowledge crept along the ledge until the broader platform was reached, upon which the most perfect of the houses alluded to stands. The ledge ended with the house, which is built out flush with its outer edge. This structure resembles in general features the cliff-houses already spoken of. The masonry is as firm and solid as when first constructed, the inside being finished with exceptional care. In width it is about 5 feet in front, the side-wall running back in a semicircular sweep; in length 15, and in height 7 feet. The only aperture was both door and window, about 20 by 30 inches in diameter. In Fig. 7 of Plate II, is a design of this aerial habitation as it appeared from below, its uniqueness consisting in its position on the face of the bluff. To the casual observer, it would not be noticed once in fifty times in passing, so similar to the rocks between which it is plastered does it appear from our position on the trail. A short distance to the right, and on the ledge above, is another building of somewhat ruder construction, but with corners square, and the walls truncated.

Referring again to Plate III and Fig. 13, the position of these houses, and also of the one in Fig. 12, can be seen in the dark heavy lines near the summit, just above the most precipitous portion of the bluff, generally at a height of from 600 to 800 feet above the level of the cañon.

This was the last cliff-house we noticed in this cañon. From the first to the last, all that were upon an elevation, however slight, were on the western side of the cañon, with either doors or windows facing east, overlooking the opposite bluffs. We could not find even the faintest vestige of ruins or houses upon the eastern side. Those built low down on the level land did not hold to the same rule, being scattered indiscriminately upon either bank of the stream.

Proceeding down the broad open cañon over the now very easy trail, we espied upon the opposite side of the stream a tower of apparently greater dimensions than the ones noticed above. The crossing was execrable; but, forcing a way through the tangled undergrowth to the stream, a way was found out of it to the ruin some forty rods back; (see Figs. 2 and 3.) The tower only remained; this is circular, 12 feet in diameter, and now about 20 in height, the wall being about 16 inches in thickness. Facing the valley northward is a window-like aperture, about 18 by 24 inches in size; the lower lintel some 7 or 8 feet above the base. The stones of which it is constructed are uniform in size and angle. Being so entirely exposed to atmospheric influences, the mortar has worn away entirely from between the outer layers. Inside, the *débris* was heaped up nearly to the window. By referring to Fig. 3, it will be seen that a rectangular structure, divided into two apartments, each about 15 feet square, joins the tower. Only one corner of three or four courses of masonry remains, shown in the sketch by the shaded lines; the rest being indicated by mound-like lines of loose *débris*, in which but few stones remain; from which fact, and also that the center of each square is considerably depressed below the surrounding surface, it is probable that they are underground apartments, their roofs not reaching the window midway in the tower. It would be extremely interesting to excavate upon these old foundations; for there is no doubt that many interesting relics, and possibly some clue to their manner of life, might be found. Our time, however, was too limited to admit of the experiment, much as we desired the information it might furnish.

In the same neighborhood stands a corner and a portion of a doorway of a house, (see Fig. 4), showing considerable care and skill in its con-

Plate VI.

CAVE DWELLINGS, IN THE CAÑON OF THE MCELMO.

ruction, and what we had not noticed before, the doorway facing east a little over 6 feet in height, tall enough to enable a person to stand up in it.

With these, we finished our observations of the ruins in the Cañon de los Mancos. We were now at its mouth, the *mesa* ending as abruptly as it began; the river turning well westward and following approximately the course of the San Juan, joins it near the southwestern corner of the Territory, at the foot of El Late.

Striking off to the right from the stream, and following close under the bold escarpment of the *mesa*, we could still discern, as we bore away, group after group of standing walls and mounds, extending down the valley into the broad open plain of the San Juan. It was with many regrets that we turned our backs upon these relics of a forgotten race. Our trail now lay over the peculiar marly earths lying under the sandstones of the table-land, soft, friable, and dusty, without vegetation, our mules' feet sinking into it to the fetlocks at each step. At our right, portions of the *mesa* have become separated and weathered into peculiar pinnacled turrets. One particularly stands out detached some fifty rods; the trail passing between it and the *mesa*, forming an old and well-known landmark on the old Spanish trail from Santa Fé to Salt Lake. A little farther on, and to the right, is another mass, bearing a curious resemblance to a matron standing with a child beside her, the alternating bands of red and white strata marking off the figure into its different proportions and into flounces and trimmings.

Away to the south and west, over the broad plains of the San Juan, where roam the great flocks of sheep and goats belonging to the Navajos, the Callabassas Mountains rear themselves into distinct view; while between them and the river, a great *cristone* thrusts itself up out of the earth to a height of at least 2,000 feet, as veritable a needle as was ever christened such.

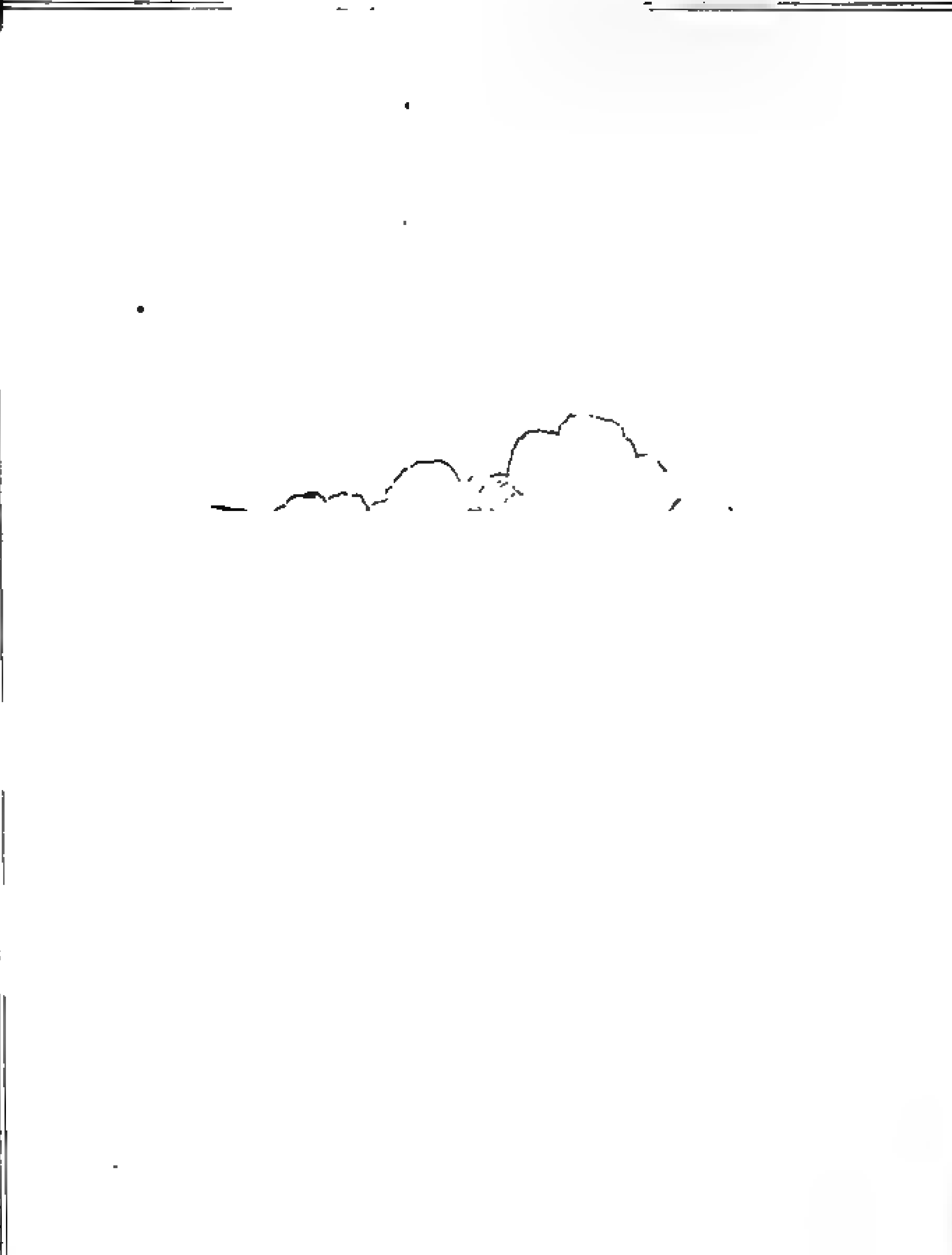
Striking into this old trail, we bore around to the western side of the *mesa*, and, near nightfall, arrived at the extensive group of ruins about "Aztec Springs," lying out upon the northeastern flanks of El Late, and close upon the divide between the waters of the Mancos and the McElmo. It was our intention to have camped here and worked up the surroundings at our leisure; but, very much to the surprise of our guide, the spring was perfectly dry, not even the least moisture remaining to tempt us to dig for it, for others before us had dug to the depth of three or four feet with no reward for their labor. At its best, it could have been but a very insignificant source of supply; the surplus oozing away through a few yards of wiry grass into the dry sand. The basin of the spring lay in quite a depression, that had evidently been excavated for the purpose. A well may have existed; for it cannot be reasonably supposed that the very large settlements which at one time existed in the neighborhood were supplied from it in anywhere near its present condition. The nearest running water was 12 or 13 miles away, and none of the surroundings indicated that this spring ever had any very considerable volume of water. Immediately adjoining the spring, on the right, as we face it from below, is the ruin of a great massive structure of some kind, about 100 feet square in exterior dimensions; a portion only of the wall upon the northern face remaining in its original position. The *débris* of the ruin now forms a great mound of crumbling rock, from 12 to 20 feet in height, overgrown with artimisia, but showing clearly, however, its rectangular structure, adjusted approximately to the four points of the compass. Inside this square is a circle, about 60 feet in diameter, deeply depressed in the center. The

space between the square and the circle appeared, upon a hasty examination, to have been filled in solidly with a sort of rubble-masonry. Cross-walls were noticed in two places; but whether they were to strengthen the walls or divided apartments could only be conjectured. That portion of the outer wall remaining standing is some 40 feet in length and 15 in height. The stones were dressed to a uniform size and finish. Upon the same level as this ruin, and extending back some distance, were grouped line after line of foundations and mounds, the great mass of which is of stone, but not one remaining upon another. All the subdivisions are plainly marked, so that one might, with a little care, count every room or building in the settlement. Below the above group, some two hundred yards distant, and communicating by indistinct lines of *débris*, is another great wall, inclosing a space of about 200 feet square. Only a small portion is well enough preserved to enable us to judge, with any accuracy, as to its character and dimensions; the greater portion consisting of large ridges flattened down so much as to measure some 30 or more feet across the base, and 5 or 6 feet in height. This better-preserved portion is some 50 feet in length, 7 or 8 feet in height, and 20 feet thick, the two exterior surfaces of well-dressed and evenly-laid courses, and the center packed in solidly with rubble-masonry, looking entirely different from those rooms which had been filled with *debris*, though it is difficult to assign any reason for its being so massively constructed. It was only a portion of a system extending out into the plains, of much less importance, however, and now only of indistinguishable mounds. The town built about this spring is nearly a square mile in extent, the larger and more enduring buildings in the center, while all about are scattered and grouped the remnants of smaller structures comprising the suburbs.

It was sunset by the time we had secured the photographic views necessary to illustrate the leading features of this group. A camp had to be found, a thing very easily done in most localities, but here one very important constituent was wanting. Sage-brush and grass abounded, but water was sadly deficient. However, by good luck, as we might call it, a few pools of the grateful fluid were found in the nearly dry bed of an old stream, about four miles distant from the ruins. This pretense of a stream known locally as the McElmo, flows westwardly into the San Juan; and is for the greater portion of the year but a deep dry gulch.

A short distance above our camp, and upon the top of the *mesa*, which, at this point, is not more than 25 feet above the valley, we found a tower very similar to that on the Mancos (see Fig. 1), but considerably larger, and surrounded by a much greater settlement. It is about 50 feet in diameter, and, like the Mancos one, double-walled, the space between the two about 6 feet in width, and subdivided into small apartments by cross-walls pierced with communicating doors or windows. Immediately surrounding this tower is a great mass, of which it is the center, of scattered heaps of stone *débris*, arranged in rectangular order, each little square with a depressed center, suggesting large subdivided buildings, similar to the great community-dwellings of the Pueblos and Moquis and the old ruins of the Chaco. Upon the southeast corner of this group, and upon the very edge of the *mesa*, are the remains of another smaller tower, and below it, founded upon the bottom of a small cañon, which ran up at right angles to the McElmo, is a portion of a heavy wall rising to the base of this lesser tower. This group covers a space of about one hundred yards square; while adjoining it on the *mesa* is group after group upon the same general plan,

Plate VII.



Watch-Tower, in the Cañon of the McElmo.

a great central tower and smaller surrounding buildings. They cover the whole breadth and length of the land; and, turn which way we would, we stumbled over the old mounds and into the cellars, as we might call them, of these truly aborigines. The same painted, glazed, and otherwise ornamented ware, of which I have spoken, accompanies each settlement, and we were continually picking up new designs and forms.

Starting down the cañon, which gradually deepened as the table-land rose above us, we found upon each hand very old and faint vestiges of the homes of a forgotten people, but could give them no more attention than merely noting their existence. Half a dozen miles down, and we came upon several little nest-like dwellings, very similar to those in Figs. 5 and 7, but only about 40 or 50 feet above the valley. Two miles farther, and we came upon the tower shown in Fig. 9, standing upon the summit of a great square block of sandstone, some forty feet in height, detached from the bluff back of it. The building, upon its summit, is square, with apertures like windows upon two faces, looking east and north, and very much ruined, but still standing in some places about 15 feet above the rock on which it is built. At the base of the rock is a wall running about it, a small portion only remaining, the rest thrown down and covered with *débris* from the house above.

About here we crossed the boundary-line into Utah, and then, two or three miles farther, we came upon a very interesting group. The valley, at this place, widens out considerably, and in the center stands a solitary butte of dark-red sandstone, upon a perfectly bare and smooth floor of the same, dipping down to the center of the valley at a slight inclination. The butte, a remnant of a former *mesa*, worn down by time to its present dimensions, is about 100 feet in height and 300 in length; an irregular mass, seamed and cracked, and gradually going the way its former surroundings have traveled. Running about its base, in irregular lines, are remains of walls, but whether for defense or habitation would be hard now to determine. At the back of the rock, a view of which is had in Fig. 10, are the remains of two quite considerable walls, one above the other; the lower portion—one corner only of a square building, all traces of the remaining portions having entirely disappeared—seemed to serve as a sort of approach to the larger building above, the top of which came up nearly to the summit of the rock. It is about 18 feet in length and 12 feet in height. Portions only of the side-walls, connecting it with the rock, remain. The stones of which it is built are very uniform in size, angle, and finish, more so than any yet seen, but, like all similarly-exposed buildings, the mortar is washed or worn away entirely from between the outer layers; farther in, it is intact as usual. In front is a single aperture of about 18 by 24 inches, whether for door or window would be hard to guess. The only access to the top of the rock was through the window of this house. On top are evidences of some sort of mason-work, that covers it from one end to the other. All the irregular gaps and crevices have been walled up, probably to make an even surface. But few of the stones remain in position; in one or two places, three or four courses, all the rest are thrown down and scattered.

In the rear, about fifty yards removed, are other ruins belonging to the group, surrounding the rock. The better-preserved portions consist of a square tower, with one round corner, about 12 feet in diameter, and upon the lowest side—which stands in a dry run—about 20 feet in height. The walls are 18 inches in thickness with no signs of apertures. Adjoining this ruin is another, but so much thrown down as to be almost

unrecognizable; and between these and the rock were circular depressions of some considerable depth, indicating either subterranean apartments or reservoirs. No water could be found anywhere in the neighborhood. The dry bed of the McElmo was fully a mile distant, in which water occurs during the winter and spring only.

Aside from the interest attaching to the ruins themselves, there are thrown about this rock and its surroundings the romance and charm of legendary association. The story runs thus, as given us by our guide, and very excellently rendered by Mr. Ingersoll, in his article to the New York Tribune of November 3:

Formerly, the aborigines inhabited all this country we had been over as far west as the headwaters of the San Juan, as far north as the Rio Dolores, west some distance into Utah, and south and southwest throughout Arizona and on down into Mexico. They had lived there from time immemorial--since the earth was a small island, which augmented as its inhabitants multiplied. They cultivated the valley, fashioned whatever utensils and tools they needed very neatly and handsomely out of clay and wood and stone, not knowing any of the useful metals; built their homes and kept their flocks and herds in the fertile river-bottoms, and worshiped the sun. They were an eminently peaceful and prosperous people, living by agriculture rather than by the chase. About a thousand years ago, however, they were visited by savage strangers from the North, whom they treated hospitably. Soon these visits became more frequent and annoying. Then their troublesome neighbors—ancestors of the present Utes—began to forage upon them, and, at last, to massacre them and devastate their farms; so, to save their lives at least, they built houses high upon the cliffs, where they could store food and hide away till the raiders left. But one summer the invaders did not go back to their mountains as the people expected, but brought their families with them and settled down. So, driven from their homes and lands, starving in their little niches on the high cliffs, they could only steal away during the night, and wander across the cheerless uplands. To one who has traveled these steppes, such a flight seems terrible, and the mind hesitates to picture the suffering of the sad fugitives.

At the *cristone* they halted, and probably found friends, for the rocks and caves are full of the nests of these human wrens and swallows. Here they collected, erected stone fortifications and watch-towers, dug reservoirs in the rocks to hold a supply of water, which in all cases is precarious in this latitude, and once more stood at bay. Their foes came, and for one long month fought and were beaten back, and returned day after day to the attack as merciless and inevitable as the tide. Meanwhile, the families of the defenders were evacuating and moving south, and bravely did their protectors shield them till they were all safely a hundred miles away. The besiegers were beaten back and went away. But the narrative tells us that the hollows of the rocks were filled to the brim with the mingled blood of conquerors and conquered, and red veins of it ran down into the cañon. It was such a victory as they could not afford to gain again, and they were glad, when the long fight was over, to follow their wives and little ones to the south. There, in the deserts of Arizona, on well-nigh unapproachable isolated bluffs, they built new towns, and their few descendants, the Moquis, live in them to this day, preserving more carefully and purely the history and veneration of their forefathers than their skill or wisdom. It was from one of their old men that this traditional sketch was obtained.

The bare floor of nearly white sandstone, upon which the butte stands, is stained in gory streaks and blotches by the action of an iron constituent in the rocks of another portion of the adjoining bluffs, and this feature probably gave rise to the legend. Half a mile back, or north from this historic butte, is a group of small cave-houses. A long bluff line, about 100 feet in height, of alternating bands of red and white sandstone, has, along a line of its upper strata, quite a number of shallow caves, in which are snug little retreats, securely walled in, the masonry perfect and substantial. Along the top of the bluff are traces of old walls, but now well-nigh obliterated.

While passing the mouth of a wide side-cañon, coming in from the right, a tall, black-looking tower caught our eye, perched upon the very brink of the *mesa*, overlooking the valley. Tying our riding-animals at the foot, and leading the pack-mule, with photographic kit, we soon

Ruins in the Cañon of the Hovenweep, Utah.

struck into an old trail, worn deep into the rocks, winding and twisting among great bowlders, and overgrown and obstructed with rank growth of sage, cedar, and cacti. In its day, the trail had been a good one; now it was anything but such. Bad as it was, however, it was the only way to the summit, and we were thankful for it. Skirting the edge of the *mesa* a few yards, we came to the tower, the trail passing back of it and on up to a higher level. A huge block of sandstone has rolled down from the escarpment of the *mesa* above, lodging upon the very brink of a bench midway between top and bottom, and upon this the tower is built, so that from below both appear as one. They are of the same diameter, about 10 feet, and some 18 feet in height, equally divided between rock and tower. In construction, it is similar to those already described, of single wall. It was evidently an outpost or watch-tower, guarding the approach to a large settlement upon or beyond the *mesa* lying above it. From this point we now struck out for another group of ruins lying upon a nameless stream, some eight or ten miles farther west. Four or five miles we followed the McElmo down, the trail good, the whole surface covered with a dense growth of artemisia and groves of cedar and piñon, with cottonwoods fringing the dry stream. Branching off at right angles, crossing the heads of two cañons which opened out quickly into great gorges, and then descending into a valley densely covered with greasewood, we came upon the ruins we were in search of. Through the valley ran a deep gulch, a narrow thread of warm, brackish water appearing at intervals in its bed, and gathering into pools in basins a short distance below the ruins.

In Fig. 11 of Plate III, is a sketch of a ground-plan of the "city," showing its general arrangement. The stream referred to, and shown in the sketch, sweeps the foot of a rocky sandstone ledge, some 40 or 50 feet in height, upon which is built the highest and better-preserved portion of the settlement. Its semicircular sweep conforms to the ledge; each little house of the outer circle being built close upon its edge. Below the level of these upper houses some 10 or 12 feet, and within the semicircular sweep, are seven distinctly-marked depressions, each separated from the other by rocky *débris*, the lower or first series probably of small community-houses. Upon either flank, and founded upon rocks, are buildings similar in size and in other respects to the large ones on the line above. As paced off, the upper or convex surface measured 100 yards in length. Each little apartment is small and narrow, averaging 6 feet in width and 8 feet in length, the walls being 18 inches in thickness. The stones of which the entire group is built are dressed to nearly uniform size and laid in mortar. A peculiar feature here is in the round corners, one at least appearing upon nearly every little house. They are turned with considerable care and skill, being true curves solidly bound together.

With this last our observations of these interesting relics came to an end. Our trip was short and rapid, and instituted in the first place, as I have said, in quest of the picturesque, and we found it. For a much more complete and faithful exposition of this interesting subject, the reader is referred to a series of photographic views from which the accompanying illustrations are drawn.

I cannot close without extending thanks to Capt. John Moss, of La Plata, our volunteer guide, who accompanied us over the route comprising the ruins. To his accurate knowledge of their locality, and the best way to reach them, as well as of the language of the Indians, is due much of the success of the trip.

ZOÖLOGY.

REPORT OF ERNEST INGERSOLL.

REPORT ON THE NATURAL HISTORY OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES, 1874.

BY ERNEST INGERSOLL, ZOÖLOGIST.

NEW YORK, *March* 1, 1876.

SIR: I herewith forward the subjoined report of zoölogical work done during the season of 1874 in connection with the survey under your direction, a preliminary account of which was published by you in the Bulletin of the Survey, second series, No. 2, under date of May 14, 1875; and I remain, with high respect, yours, etc.,

ERNEST INGERSOLL,
Zoölogist.

Dr. F. V. HAYDEN,
U. S. Geologist, Washington, D. C.

The material herein reported upon consists of two collections, chiefly of mollusks: one made by Mr. E. A. Barber, of West Chester, Pa., in the northwestern part of the Territory; and the other made by the writer in connection with the Photographic Division of the Survey during July, August, and September of 1874, in which he was assisted by Master Frank Smart, of Washington.

Mr. Barber was attached to Mr. Marvine's Topographical Party, and collected plants and shells in North Park, along Bear and White Rivers, and at the White River agency, where he was engaged in making barometric observations for several weeks. His collection is not large, but is interesting in that it exhibits several species which I did not find, and also includes additional examples of the new *Microphysa*, which was described by Mr. Bland from my specimens.

My own route lay from Denver west into Middle Park, thence south up the valley of the Blue to Hoosier Pass, leading the party into South Park, from which we crossed over to the Arkansas, and thence through Poncha Pass into San Luis Park, and across to Saguache. From here the road led west to the Los Pinos Indian agency, and then southwest through Antelope Park to Baker's Park, in the high mountains.

At this point, the camp was stationed; and leaving Mr. Smart to collect here, I accompanied Mr. Jackson on a side-trip of nearly three weeks' duration, made southwest into the valley of the Rio San Juan, at the extreme corner of the Territory. On our return trip from Baker's Park, we followed the Rio Grande to Del Norte, thence struck across the San Luis plain to the "sand-hills," through Mosca Pass, Huerfano Park, Wet Mountain Valley, and Oak Creek, and finally came to Cañon City, where I left the party.

Collections were made at nearly every camp on the whole route, and that they do not make a greater aggregate is due to the inexperience of the writer, the haste with which the party moved, and not a little to the comparative scarcity of those objects in which he happened to take the most interest, and most desired to have completely represented. In such cases, in the absence of specimens or affirmative evidence, a cer-

tain amount of negative evidence appears, which may be of value in future deductions. I append a list of the localities, remarking upon elevation and so forth, at which collections were made. The absence of any camp, as Nos. 12–16, from this list, does not necessarily imply that I was idle, but that nothing of importance reached home from that locality.

LIST OF LOCALITIES FROM WHICH SPECIMENS WERE BROUGHT HOME.

CAMP 9: *Hot Sulphur Springs, Middle Park*, July 31 to August 5. Elevation 7,725 feet. A broad, open valley, containing hot and cold springs of various mineral-waters.

CAMP 9–10: *Grand River Valley*, August 5. About 7,500 feet. Grassy prairies and river-terraces of coarse gravel covered with sage-brush, with but little timber, except along some portions of the river-banks.

CAMP 10: *Mouth of Blue River*, August 6–8. About 7,500 feet. High river-terraces. Cottonwoods and alders along the river and about springs in the neighboring hills.

CAMP 10–11: *Blue River Valley*, August 8. 7,500–8,500 feet. Same general characteristics.

CAMP 11: *Ute Peak, Blue River Valley*, August 8. About 8,500 feet. Springy ground by a cold streamlet, with abundance of small timber and luxuriant herbage. Many shells were collected on a wooded hill 2,000 feet higher than the camp.

CAMP 17: *Head of San Luis Valley*, August 14. About 8,000 feet. Luxuriant grass and herbage; large pines and spruces. Water in plenty.

CAMP 17–18: *San Luis Valley*, August 15. 7,600–7,200 feet. Distance thirty miles, mostly *Artemisia* plains, very dry and dusty. The weather, which had been rainy, now began to be clearer, with hot noondays and cool nights.

CAMP 18: *Springs, Saguache*, August 16. 7,700 feet. Edge of dry plains. The springs come copiously from under a volcanic bluff, and flow into a marsh, which drains into Saguache Creek.

CAMP 19: *Saguache Creek*, August 16. 7,748 feet. Five miles beyond Camp 18, on the banks of the above stream, which is a tributary of the Rio Grande and waters a fertile region. Thousands of cattle are herded hereabouts.

CAMP 20: *Twenty miles west of Saguache*, August 17. About 9,000 feet. Volcanic cañon.

CAMP 21: *Los Pinos Indian agency*, August 19–24. 9,290 feet. A fertile plain watered by two creeks, and surrounded by hills, affording plenty of rain. The camp was placed among a grove of various trees by a little rocky stream. We remained a week at this point; but my time was largely occupied in studying the traits of the Ute Indians, whose southern agency is here.

CAMP 22: *White Earth Creek*, August 24. About 8,000 feet. A deep ravine, which had been recently burned over.

CAMP 23: *Timber-line; divide between the Gunnison and Rio Grande*, August 25. About 10,000 feet. Timber mostly small; no pines. Found many mollusks in the deep wet grass early in the morning.

CAMP 24: *Clear Creek*, August 26. About 9,300 feet. A tributary of the Rio Grande, emptying in Antelope Park. The banks were here covered with a riotous growth of brush and weeds.

CAMP 25: *Jennison's Ranch*, August 27–28. About 9,600 feet. On the Rio Grande, between Antelope and Baker's Parks. Fertile alluvial

bottoms, with plenty of timber on the hills. Clear, with frosty nights.

CAMP 26: *Howardville, Baker's Park*, August 29–September 23. 9,700 feet. A deep valley among immense trachyte mountains. Abundance of timber (spruce and the like, and aspen), bushes and plants. Frosty nights, and snow toward the last of our stay.

Cunningham Gulch is a deep cañon near by, on the high, perpendicular side of which, along trails leading to silver-mines, I found active mollusks and insects at an altitude of fully 11,000 feet.

CAMP D: *Cascade Creek; head of the Animas Valley*, September 3. About 8,000 feet. Southern slope of high sierras. A beautiful region in all respects. This and the four following localities were on the side-trip into the San Juan Valley.

CAMP E: *Animas Park*, September 4. About 6,600 feet. Lower down the river, where the broad bottoms are somewhat cultivated.

CAMP E–F: *Between the Rio Animas and Rio La Plata*, September 4. 8,000 feet. Half-way we passed a great pond, surrounded with rushes; the resort of innumerable wild fowl, and inhabited by a great variety of fresh-water life. Observe the note to *Helisoma trivolvis*.

CAMP F: *Rio La Plata mining-camp*, September 5–8. About 7,500 feet. Collections made in dense damp groves of evergreen and deciduous trees.

CAMP K: *Hovvenweep, Utah*, September 13. About 4,500 feet. A low, dry ravine some twenty miles into Utah, in a desolate *mesa* country, named by us Hovvenweep, from two Indian words meaning deserted cañon. Only gnarled cedars, sage-bush, and greasewood grow there. The valley must be subject to floods.

CAMP P: *Head of Mineral Creek*, September 19. About 10,000 feet. The sources of a mountain-torrent draining into Baker's Park.

CAMP 28–29: *Saint Mary's Lake, Antelope Park*, September 25. 9,300 feet. A beautiful lake without inlet or outlet, on the northeastern side of the park, surrounded by rocky cliffs. Inhabited by some peculiar shells and hosts of water-fowl, while its shores are the resort of large herds of antelope.

CAMP 30: *Rio Grande above Del Norte*, September 28. 7,560 feet. The camp was in a low spot by a sluggish stream.

CAMP 32: *Lakes, San Luis Valley*, September 20. About 7,500 feet. These lakes are most of them dry in September, and all the shells I found were dead on the beach. They are frequented by innumerable wild geese and ducks, which are tormented by the many large gulls which make the lakes their home. The waters are alkaline, and the whole region is white with saline deposits and nearly barren.

It will be observed that all of these localities are in Colorado except Camp K.

GENERAL ACCOUNT OF THE WORK.

Attention was chiefly given to fresh-water invertebrate life, though the results were not very satisfactory.

At the springs near Saguache, leeches were found, pronounced by Prof. A. E. Verrill to be *Aulostomum lacustre*, var. *tigris*, Verrill, and *Clepsine modesta*, Verrill, both of which have been found heretofore in the same region. A more thorough search, had it been possible, would probably have revealed additional forms, as the locality was extremely favorable.

For crustacea a sharp lookout was kept, but only the following species were certainly seen: two amphipods, *Gammarus robustus*, Smith,

and *Hyallela inermis*, Smith, both of which were described in the Report for 1873, which inhabited the above springs in great abundance. From the pond mentioned between camps E and F a small crab was brought home, which Prof. S. I. Smith pronounced to be a true marine form, belonging to the *Astacidœ*. That this is a survivor of the period, probably comparatively recent, when this pond was a salt-water marsh, is supported by the astonishing fact that two specimens of a young *Truncatella* and well-preserved fragments of an *Arcà* were found on the muddy shores. It would be of great interest to know whether the exuberant vegetation of the pond retains any traces of marine plants.

The insects were not methodically collected, and but few, chiefly myriapods, which are very abundant in the mountains, were brought home. A small collection of spiders consists of ten species of ARANEÆ (*Drassidœ* 2, *Lycosa* 5, *Attus* 1, *Thomisus* 2) and four species of PHALANGEÆ (*Phalangein* 3, *Gonyleptes* 1). All of these species are believed by Mr. E. H. Emerton, who has examined them, to be undescribed, though in part identical with forms previously collected in Colorado. A description is not attempted herewith, because the material is not at hand for proper study and comparison. Further collections and observation in this branch of entomology are particularly desirable from the mountainous regions of all the Territories.

Land and fresh-water shells comprise the largest part of the material brought home. They were made a specialty; and the fact that next to nothing of this class had ever been reported from Colorado, and but little was known at all of the Mollusca of the Rocky Mountain region, was deemed a sufficient excuse for what might seem too exclusive attention to this department of natural history, which does not present to the careless mind such striking attractions as the study of the higher vertebrates.

No fishes were collected, although numerous attempts were made. The majority of our time was spent where they seemed to be entirely absent, or so extremely scarce that, although all were interested in the capture of certain species, not a trout graced our table during the whole trip.

Some snakes and frogs were secured at Hot Springs, Middle Park, and a number of *Amblystoma* seen for the first and last time. Reptiles were taken wherever they occurred after this, also, except upon the long side-trip mentioned above, where it was impracticable to preserve anything greater than could be put in a pocket-bottle of alcohol. The marsh between the Animas and La Plata was a fine locality for batrachians. South of the mountains, lizards began to appear in great numbers and variety, and increased as we got farther out upon the dry plains. Camp 20 furnished us our only rattlesnake, and I do not remember any other camp at which we were even suspicious of their presence.

Such large *suites* had already been secured of the mammals and birds of Colorado that it was not deemed advisable to spend time in a systematic collection of them. Some skins were obtained, and observations recorded, but little worthy of special mention. Birds were nowhere seen so abundantly as in Berthoud Pass and on the Arkansas below Granite. The former locality, being easily accessible, ought, before many seasons, to yield a rich ornithological harvest.

In conclusion, I wish to express to Mr. Wm. H. Jackson, director of our party, the appreciation I have of his hearty co-operation and genial sympathy, through which he not only afforded me opportunities I would not otherwise have had, but added immensely to my personal enjoyment of this delightful trip.

SPECIAL REPORT ON THE MOLLUSCA.

The collection of Mollusks fairly represents the land and fresh-water families, and comprises many additions to the fauna of Colorado, as well as the following six species, believed to be new:

Limax montanus, Ingersoll.
Limax castaneus, Ingersoll.
Microphysa Ingersolli, Bland.
Pupilla alticola, Ingersoll.
Helisoma plexata, Ingersoll.

With respect to their distribution, it will be seen that none were found on the eastern slope of the range, although there is no conclusive evidence that they do not exist there; that there was a marked increase as we advanced south; that altitude seemed to have little influence upon their range so long as other favorable conditions were present; and that some species (as of *Helisoma*) had a very local distribution. The genera *Zonites*, *Vitrina*, *Vallonia*, *Pupa*, *Succinea*, and *Pisidium* were wide-spread. Among the Helices, *Patula Cooperi* only occurred in broad open valleys; *Patula striatella* and *Cronkhitei* were found together over the northern portion of the district traversed, but in the south the latter replaced *striatella*. The little *Microphysa*, occurring abundantly on the cliffs in Baker's Park up to 11,000 feet, and in the Animas and other valleys draining into the Rio San Juan, was also found in the North Park by Mr. Barber, but his examples were less robust. All the other species of this genus belong to Florida and the Gulf coast. The *Pupæ* were perhaps the most common forms, increasing as we went south, where specimens of *Vertigo californica* and *Pupilla alticola* were numerous everywhere on the mountains as high up as timber grows. *Pupilla Blandi*, heretofore known only as a fossil in Missouri River Drift, was collected alive in considerable numbers.

In order to make this list as far as practicable a statement of our present knowledge of the Mollusca of that portion of the United States lying between the Rocky Mountains on the east and the Sierra Nevada on the west, designated, by Mr. W. G. Binney, *The Central Province* (Bulletin Mus. Comp. Zoöl., III, IX), I have inserted in their proper systematic place the names of such mollusks as I could ascertain to have occurred within that region, distinguishing those species which form my own list by the black head-letter type. A brief mention of the range extralimital to the scope of this paper is added to most species.

There seems some reason to doubt whether the limits assigned by Mr. Binney in his Geographical Catalogue, above referred to, circumscribe a true zoölogical province, considered with reference to the Mollusca; but I have contented myself with carefully tabulating such observations as I had access to, leaving to others such deductions as the facts may warrant. Enough is presented, however, it seems to me, to show that the Central Province, so-called, is not so deficient as has been supposed, either in the number of species or in representatives of adjoining faunas. The impression that this inter-montanic region is unfavorable to the development of Pulmonates also seems wrong, except in respect to the scarcity of lime, to which cause we may probably attribute the fact that the more minute forms are in large majority. A further discussion of the geographical and hypsometric distribution of the Mollusks of the

Rocky Mountains may be found in an article by the author in the *Popular Science Monthly* for May, 1876.

It gives me pleasure to acknowledge my indebtedness and tender my thanks to Messrs. Thomas Bland and W. G. Binney, Dr. James Lewis and Prof. Edward S. Morse, for much kind help and good counsel, both before and after the completion of this manuscript.

MOLLUSCA.

Class GASTEROPODA.

Order PECTINIBRANCHIATA.

Family VALVATIDÆ.

Valvata sincera, SAY.

Lakes; San Luis Valley .... **1 specimen.**

Reported also from Salt Lake (*Hemphill*). Inhabits the Western States.

My single shell was found dead upon the beach. It is typical, except in size, which exceeds that of any other specimens I have seen. I agree with Mr. W. G. Binney that I have never seen "specimens referred to this species that can easily be distinguished from carinate forms of *V. tricarinata*."

Valvata virens, Tryon.—Cœur d'Alêne Lake, Montana (*Hemphill*); Pacific coast.

RISSOIDÆ.

AMNICOLINÆ.

Tryonia clatharata, Stm.—Colorado Desert (*Blake*).
Tryonia protea, Gld.—Colorado Desert (*Blake*.)

Somatogyrus isogonus VAR. **subglobosus**, SAY.

Lakes; San Luis Valley .... **5 specimens.**

Northwestern part of the Union (*Say*).

All my specimens were dead. My time was so limited at this interesting point that I could not search the deep water for living mollusks.

Amnicola turbiniformis, Tryon.—Crane Lake Valley and Surprise Valley, Northeast California (*Gabb*); near Fort Hall, Idaho (*Reid*); Truckee, Nevada (*Carlton*). California.

Amnicola longinqua, Gld.—Colorado Desert (*Blake*).

Fluminicola Nuttalliana, Stm.—Warm Springs, near Salt Lake, Utah (*Reid*); Upper Des Chutes River, and Klamath River, Oregon (*Newberry*). Oregon and California.

Fluminicola seminalis, Stm.—Salt Lake, Utah (*Reid*); Oregon and Washington Territory (*Newberry*).

Fluminicola Hindsii, Stm.—Salt Lake, Utah (*Reid*); River Kootanie and stream at foot of Rocky Mountains, 4,626 feet, British Columbia (*Lord*).

The last two of these three species are considered identical with the first by Mr. Binney and some others; their range seems to be co-extensive.

Fluminicola fusca, Hald.—Shores of Lake Utah (*Burton*); Sacramento River, California, to Green River, Utah (*Cooper*).

POMATIOPSINÆ.

Pomatiopsis intermedia, Tryon.—Owyhee River, Southeast Oregon (*Gabb*); White Pine district, Nevada (*Hemphill*). Pacific coast.

MELANIIDÆ.

Goniabasis plicifera, Lea.—Rivers of Washington Territory (*Cooper*). Pacific coast.

Goniabasis silicula, Gld.—Usually regarded as a variety of the above. Quoted from Washington Territory; Oregon; Hell-Gate River, Montana; and the Missouri above the Falls (*Cooper*). Pacific coast.

Goniabasis Newberryi, Lea.—Upper des Chutes River, Oregon (*Newcomb*). California.

Goniabasis nigrina, Lea.—Clear Creek, Shasta County, California. Pacific coast.

Goniabasis Draytoni, Lea.—Walla Walla, Oregon; Clear Creek, Shasta County, California. Pacific coast.

Leptoxis fusca, Hald.—Shores of Lake Utah (*Burton*). Pacific coast.

Order PULMONATA.

PUPIDÆ.

PUPINÆ.

Cionella subcylindrica, LINNÆUS.

Camp 24: Clear Creek .... 3 specimens.

These three were found in wet grass and bushes, some 8,300 feet above the sea. Though I searched particularly for them afterward, no more were obtained. It is a circumpolar species.

Pupilla muscorum, LINNÆUS.

Camp 11: Blue River Valley .... 1 specimen.
Camp 21: Los Pinos Agency .... 5 specimens.

Canada; Eastern States; Europe.

Pupilla Blandi, MORSE.

Camp 24: Clear Creek .... 2 specimens.
Camp 26: Cunningham Gulch .... 40 specimens.
Camp D: Animas Valley .... 1 specimen.
Camp F: Rio La Plata .... 1 specimen.

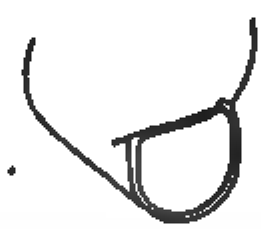
Sub-fossil in Drift on Missouri River near Fort Berthold.

Pupilla alticola, SP. NOV.

Animal not observed.

Shell perforate, straight, two and one-half times as long as broad, densely striate, subtranslucent, chestnut-brown; apex obtuse; whorls 6 *or* 7, *convex,*

the middle three of the spire equal, causing a parallelism in the sides of the shell, the last noticeably greater, expanding toward the aperture, not closely appressed to the body-whorl; suture deeply impressed; aperture small, oblique, subtriangular, margins connected by a thin deposit, without internal processes; peristome simple, somewhat reflected over the umbilicus. Length, 2¾ mm.; diameter, 1 mm.



Camp 26: Cunningham Gulch	25 specimens.
Camp F: Rio La Plata	5 specimens.

It will not be difficult to recognize this species by its parallel sides, base-like expansion of the last whorl, coarse incremental lines, and edentate aperture. It seems to be an essentially alpine species, none having been found at an elevation less than 8,000 to 9,000 feet. It was plenty in the localities mentioned above.

Leucochila arizonensis, Gabb.—Fort Grant, Arizona (*Horn*); Pike's Peak, Colorado (*Tryon*); White Pine, Nevada (*Hemphill*). California.

Leucochila hordeacea, Gabb.—Fort Grant, Arizona (*Horn*).

VERTIGININÆ.

Vertigo californica, ROWELL.

Camp 11: Blue River Valley	15 specimens.
Camp 21: Los Pinos agency	3 specimens.
Camp 23: Divide southwest of Los Pinos	3 specimens.
Camp 26: Howardville	50 specimens.
Camp D: Animas Valley	2 specimens.
Camp F: Rio La Plata	4 specimens.

Pacific coast.

Vertigo corpulenta, MORSE.

Camp 21: Los Pinos agency	2 specimens.
Camp 23: Divide southwest of Los Pinos	1 specimen.

Eastern slope Sierra Nevada (*Stretch; Hemphill*).

Vertigo ovata, Say.—Fort Grant, Arizona (*teste Binney*). Eastern United States.

HELICIDÆ.

VITRINÆ.

Macrocyclis vancouverensis, Lea.—Idaho; west side of Cœur d'Alêne Mountains, in forests of Coniferæ (*Cooper*); Sumass Prairie, Fraser River (*Lord*). Pacific coast.

Zonites arboreus, SAY.

Camp 9: Hot Sulphur Springs	3 specimens.
Camp 11: Blue River Valley	13 specimens.
Camp 26: Howardville, Baker's Park	22 specimens.
Camp F: Rio La Plata	3 specimens.
North Park (*Barber*)	2 specimens.

"Damp bottom-lands along the lower valley of Hell-Gate River, Montana" (*Cooper*); Washoe County, Nevada; Montana; Rio Chama, New Mexico (*Binney* and *Bland*). United States generally.

Zonites viridulus, MENKE.

Camp 11:	Blue River Valley	2 specimens.
Camp 19:	Saguache Creek	12 specimens.
Camp 20:	Twenty miles west of Saguache	1 specimen.
Camp D:	Cascade Creek, Animas Valley	3 specimens.
Camp F:	Rio La Plata	4 specimens.

I find no other localities for this mollusk recorded in the inter-montanic region, except that Mr. Lord mentions finding a "*Zonites* like *electrina*, Fort Colville, Columbia River"; and Mr. Binney accredits it to the Central Province. All my own localities were at the foot of mountains, and in each case the animals were found in the wet shaded ground beside running water. In the valleys of the Animas and La Plata, they were very abundant under logs. It is distributed over the United States generally, except on the Pacific coast.

Zonites indentatus, Say.—Accredited by Mr. Binney (Bull. Mus. Comp. Zoöl., III, ix, 202) to the Central Province (Utah) as having been derived from the north. Eastern North America.

Zonites nitidus, Müll.—Colorado (*Carpenter*). Europe, New York, Ohio, and British America.

Zonites Whitneyi, Newc.—Lake Tahoe, Sierra Nevada, 6,100 feet (*Cooper*); Truckee, Nevada (*Carlton*).

Zonites Breweri, Newc.—Truckee, Nevada (*Carlton*); Lake Tahoe (*Newcomb*). California coast.

Zonites minusculus, Binney.—Accredited in Binney's catalogue to the Central Province; Fort Grant, Arizona (*Horn*). All of North America and the West Indies.

Zonites conspectus, BLAND.

Camp 26:	Cunningham Gulch, altitude 11,000 feet	1 specimen.

No mention has been made of this species that I am aware of since its description by Mr. Thomas Bland (Ann. N. Y. Lyc. N. H., VIII, 163), who quotes San Francisco, California, as its habitat.

Zonites fulvus, DRAPERNAUD.

Camp 9:	Hot Sulphur Springs	5 specimens.
Camp 10:	Mouth of Blue River	5 specimens.
Camp 20:	Twenty miles west of Saguache	2 specimens.
Camp 24:	Clear Creek	35 specimens.
Camp 26:	Howardville, Baker's Park	25 specimens.
Camp D:	Animas Valley	10 specimens.
Camp F:	Rio La Plata	6 specimens.
Camp P:	Head of Mineral Creek	25 specimens.
North Park (*Barber*)		5 specimens.

Found heretofore in the White Pine district (*Hemphill*) and Truckee Valley (*Carlton*) of Nevada; and at Lake Tahoe (*Cooper*). North America, and boreal regions generally.

The specimens vary in size and proportion, many being young. The highest localities, it will be noticed, yielded the greatest number of specimens, as Camp 24 (9,300 feet), Camp 26 and Camp P (10,000 feet).

Vitrina limpida, GOULD.

Camp 24:	Clear Creek, Northeast Antelope Park.....	25 specimens.
Camp 26:	Howardville, Baker's Park	3 specimens.
Camp D:	Animas Valley	12 specimens.

I do not find this species anywhere recorded from the central basin. It was, therefore, after long hesitation that I separated these specimens from the following species, which includes the majority of the *Vitrinæ* collected, and has a co-extensive distribution in the Rocky Mountains. The recorded range of the present species is eastward from Lake Superior.

Vitrina Pfeifferi, NEWCOMB.

Camp 21:	Los Pinos agency	25 specimens.
Camp 23:	Divide southwest of Los Pinos............	15 specimens.
Camp 26:	Howardville, Baker's Park	40 specimens.
Camp F:	Rio La Plata	4 specimens.
Camp P:	Head of Mineral Creek....................	6 specimens.

Carson Valley, Nevada (*Newcomb*); Lake Tahoe (*Cooper*); head of Gunnison River, Colorado (*Carpenter*). Western slopes of the Sierra Nevada.

It will be noticed that all my localities are southern, but at a great elevation, shells from Mineral Creek having been collected in a snow-storm. It is well known that "the animal is very hardy; for, according to Nilson, it is found crawling about among leaves in the southern part of Sweden in the depth of winter, and it is also found in the most northern part of that country." The gentlemen of the United States Exploring Expedition found their specimens of *Vitrina* almost universally on the tops of mountains.

Limax montanus, SP. NOV.

Color bluish-gray; form stout, with blunt posterior extremity; length exceeding one inch; color brown, with mantle, head, tentacles and eye-peduncles black; bottom of foot white.

1, Jaw. 2, Lingual dentition. 3, Genitalia: *a*, external orifice; *b*, genital bladder; *c*, oviduct; *d*, testicle; *e*, epididymis; *f*, ovary; *g*, vas deferens; *h*, penis-sac.

Jaw as usual in the genus. Lingual membrane long and narrow. Teeth 50–1–50, with 16 perfect laterals. Centrals with base of attachment slightly longer than wide; inferior lateral angles not much produced, lower margin incurved; reflection slightly shorter than one-half the base of attachment; tricuspid, the outer cusps short, stout, bearing short, stout cutting-points; the median cusp stout, reaching almost to the lower edge of the base of attachment, beyond which projects the cutting-point; laterals like the centrals, but unsymmetrical, as usual, by the suppression of the inner cusp with its cutting-point and inner lower lateral expansion of the base of attachment. There are 16 perfect lateral, beyond which are several teeth, forming the usual gradual transition to the marginals. These latter are aculeate, the cutting-points bearing at about the center of their lower edge a blunt spur, which is a modified form of the bifurcation of the marginal teeth often found in *Limax*. The marginal teeth have the usual characteristic arrangement in oblique rows, and the separate teeth, as they pass outward, have at first the usual rapid increase for a short distance, and thence gradual decrease in size.

A reference to the exhaustive article on the lingual dentition of American *Pulmonata*, published in the Proceedings of the Philadelphia Academy of Natural Sciences, April 27, 1875, by W. G. Binney, forming part III of volume II of his Conchological Contributions, will show (pages 172–177) that this species differs in its dentition from all the *Limaces* now known to inhabit North America. *L. flavus* and *maximus* have no cutting-points to the side-cusps of centrals and laterals. *L. Hewstoni* has well-developed inner cutting-points to its inner lateral teeth, which indeed are scarcely distinguishable from the centrals. *L. agrestis* has also a peculiar inner cutting-point to its laterals. *L. campestris* has the same type of central and lateral teeth as the species under consideration, but its inner marginals are simple, not bifid. *L. Weinlandi*, known only by its dentition, no description of its external characters or genitalia having been published (see Hynemann, Malak. Blätt., X, 212, pl. ii, fig. 1), differs from this species by having all its marginals simple.

The above comparison of the dentition is given in detail, because it is on its lingual membrane that I am forced to rely for decided specific characters, the external characters of the animal being of little value in alcoholic specimens.

In the genital system, there are no accessory organs. The penis-sac is as long as the vagina, with a constriction near its commencement, and tapers above to a point, below which it receives the vas deferens. The genital bladder is oval, with a very short duct entering the vagina above the penis-sac.

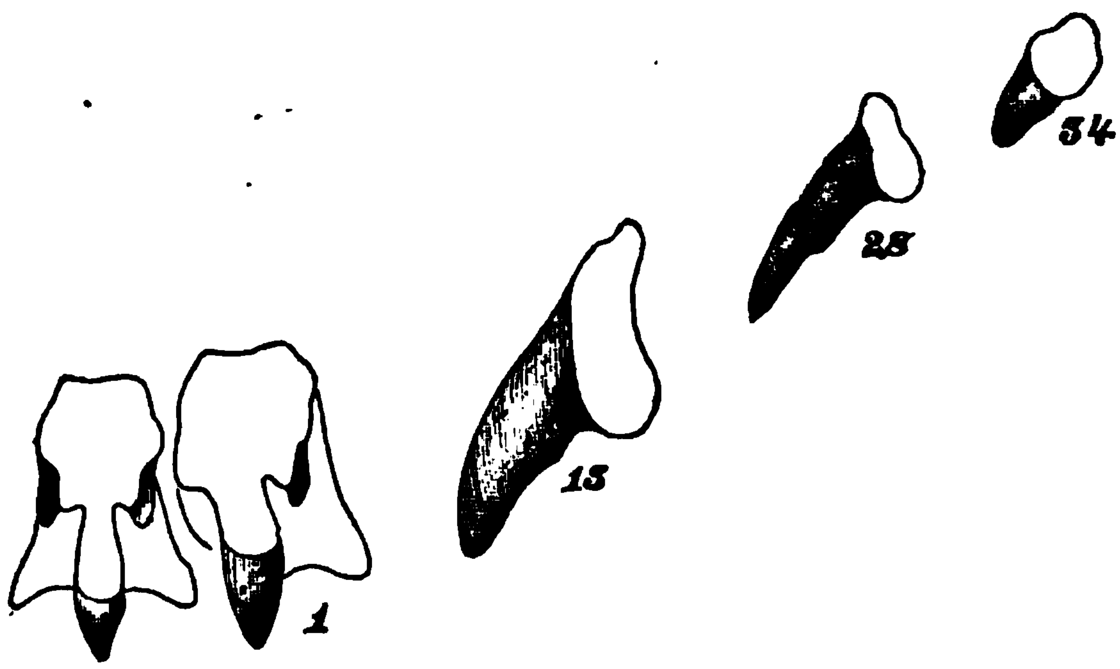
Camp 9: Hot Sulphur Springs........................ 1 specimen.

My notes taken on the spot were lost. The external characters of the animal in alcohol are unreliable; hence the brief description.

In Mr. Binney's "Notes" (vol. II, part III, 153), this slug was catalogued, among the Terrestrial Mollusks of the United States, under the name of *Limax Ingersolli*, and on pages 174 and 176 of the same work, where the circumstances of its discovery are mentioned, it was referred to as undescribed. In vol. II, part IV, of the same series (now in press), it was described as *L. montanus*, Ingersoll, but the necessity of discarding the former name was not discovered by Mr. Binney in time to make a corresponding change in the designation of the figures, which will bear the name *Limax Ingersolli*, the plates having already been made.

Limax castaneus, SP. NOV.

Small and slender; length less than one inch; color a lively brown, with a darker spot over the shield; head, tentacles, and eye-stalks black; bottom of foot white.



Lingual dentition of *Limax castaneus.*

Jaw as usual; lingual dentition as in the other form, but differing in having only 34–1–34 teeth, with 12 perfect laterals. This important difference is such as to warrant the belief that the form may prove a distinct species. Genitalia not examinued.

Camp 10–11: Blue River Valley .... 5 specimens.

The above *Limaces* were submitted to Mr. W. G. Binney for anatomical examination. The drawings and descriptions of the jaw, lingual apparatus, and genitalia of both reproduced in the figures were furnished by him, to whom really belongs the credit of discriminating their specific distinction.

Limax campestris, Binney.—Truckee, Nevada, 5,866 feet (*Cooper*), is the only other mention I can find of the occurrence of this family in the central basin; United States except Pacific slope.

HELICINÆ.

Patula Cooperi, W. G. BINNEY.

Camp 9: Hot Sulphur Springs, Middle Park .... 7 specimens.
Camp 11: Blue River Valley .... 30 specimens.
Lakes, San Luis Valley .... 2 specimens.
Northeastern Colorado (*Barber*) .... 100 specimens.

California to Nebraska; Montana to Arizona. Most of the many recorded localities are in the mountains; the highest being 5,500 feet.

This well-known *Helix*, the largest of any collected, was not uncommon in Middle Park and North Park, where great numbers of dead shells would be found in isolated spots; only a few live ones being found in wet places in the vicinity. In the Blue River Valley, crossed a belt a hundred yards or so wide, and apparently miles in length, where the surface was thickly strewn with bleached shells, as though an army of these mollusks had been overtaken on the march by universal destruction. There was a very perceptible difference between such specimens as were found in shaded, humid places and those living in open and drier

places, in that the latter had a paler, more bleached appearance, and a thicker shell.

Patula solitaria, Say.—Cœur d'Alêne Mountains, 2,500 feet (*Cooper; Hemphill.*) Mississippi Valley.

Patula strigosa, Gould.—Western New Mexico to the Big Horn Mountains of Nebraska (*Binney* and *Bland*); Montana to Arizona (*Cooper*).

Patula Hemphilli, Newc.—White Pine, Nevada, 8,000 feet (*Hemphill*).

Patula idahoensis, Newc.—Between Idaho City and Cœur d'Alêne Mountains (*Hemphill*).

Patula Haydeni, Gabb.—Weber Cañon, Utah (*F. V. Hayden*). Subfossil only.

The above-mentioned species of *Patula*, viz: *Cooperi, solitaria, strigosa, Hemphilli, idahoensis* and *Haydeni*, are remarkably connected in form. "*Patula Haydeni*, which may be considered as extinct, is distinguished by its carina and equally 'prominent, elevated, revolving ribs.' It is allied to *P. strigosa*, and more especially to the carinated form described as *P. Hemphilli*. The non-carinated *P. strigosa* is variable, sometimes difficult to be distinguished from depressed varieties of *P. Cooperi*. The rather strongly-ribbed variety of the latter, from Bear River, Utah, connects *P. idahoensis* with this group. In some specimens of that species, the obsolete carina may be observed on the periphery between the strongly-elevated oblique (not revolving) ribs. The more globose forms of *P. Cooperi* may be compared with *P. solitaria*. In the group of species of *Patula* referred to, the alliances, indicated however by the shells alone, are associated with well-marked specific differences in the genitalia; in other groups, *Mesodon*, for instance, in the dentition. Mr. W. G. Binney has lately directed attention to this interesting point."—THOS. BLAND, *letter of March* 16, 1875.

Patula Hornii, Gabb.—Fort Grant, Arizona (*Horn*).

Patula Cronkhitei, NEWCOMB.

Camp 9: Hot Springs	14 specimens.
Camp 11: Blue River Valley	20 specimens.
Camp F: Rio La Plata	15 specimens.

Recorded from Klamath Valley, Oregon (*Gabb*); White Pine Mountains, Nevada, and Northern Utah (*Hemphill*).

Patula striatella, ANTHONY.

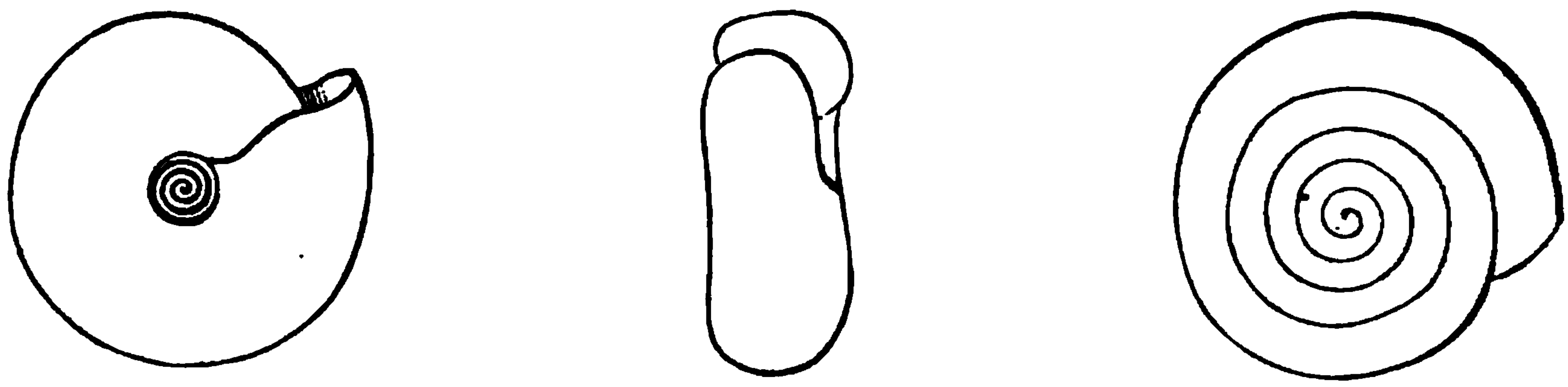
Camp 9: Hot Springs	20 specimens.
Camp 19: Saguache	5 specimens.
Camp 24: Clear Creek	20 specimens.
North Park (*Barber*)	5 specimens.

Montana? (*Cooper*); Hell-Gate River, Montana (*Binney* and *Bland*); Estes Park, Colorado (*Carpenter*). Eastern United States.

Helix (Microphysa) Ingersolli, BLAND. *Ann. N. Y. Lyc. N. H., vol. XI,* 151; *June,* 1875.

"*Shell umbilicated, discoidal, thin, translucid, nearly smooth, white; spire flat, summit subimmersed; suture impressed; whorls* $5\frac{1}{2}$, *rather convex, slowly increasing, the last not descending, more convex below the periphery; breadth of umbilicus nearly one mill.; aperture subvertical, higher*

than broad, lunate; peristome simple, acute, margins remote, columellar margin slightly reflexed, basal margin subsinuate. Greater diameter 4 mill.; height 2½ mill."



Camp 26: Baker's Park	25 specimens.
Camp 26: Cunningham Gulch, 11,000 feet	6 specimens.
Camp D: Animas Valley	25 specimens.
North Park (*Barber*)	10 specimens.

This beautiful little shell, described by Mr. Thomas Bland, from my specimens, as above, was not found by me north of the crests of the sierras about Baker's Park, but was not uncommon on their southern slopes, where I first found it clinging to vertical and all but inaccessible cliffs in Cunningham Gulch, at an altitude of over 11,000 feet, exposed to daily snow-storms; yet these specimens were, if anything, finer than those subsequently found along the Rio Las Animas. Mr. Barber's examples are all dead shells, and are not so large or perfect. They were found at an altitude not exceeding 8,000 feet, but the station is not stated.

Mr. W. G. Binney, who dissected the animal of this species, which seemed with difficulty to wholly retreat into the shell, communicated the following particulars of its anatomy:

"Jaw low, wide, slightly arcuate, ends slightly attenuated, whole anterior surface with about 22 broad, flat, slightly-separated ribs, whose ends denticulate either margin. This form of jaw is usual among the *Helicinae*. It is of the same type as *H. Lansingi* (Ann. Lyc. N. H. of N. Y., xi, 74, fig. 2). Lingual membrane long and narrow. Teeth about 16–1–16. Centrals as usual in the *Helicinæ;* the side-cusps and cutting-points are well developed, the base of attachment longer than wide. Laterals of same type, but unsymmetrical, and consequently only bicuspid. The change from laterals to marginals is very gradual, there being no splitting of the inner cutting-point. Marginals low, wide, with one inner, long, blunt cutting-point, and one outer small, blunt cutting-point."

Helix lineatus, Say.

Camp D: Animas Valley .... 1 specimen.

Rio Chama, N. Mex. (*Binney* and *Bland*); Salmon River, Idaho (*Hemphill*). North America except Pacific coast.

Helix Polygyrella, Bld. and J. G. Cp.—Common on Cœur d'Alêne Mountains (*Cooper*).

Helix Columbiana, Lea.—Hell-Gate Valley, Montana (*Hemphill*); Fraser River (*Lord*). Pacific coast.

Helix devia, Gld.—Intruding into Idaho (*Binney*); Deer Lodge Valley, Montana (*Hemphill*). Pacific coast.

Helix loricata, Gld.—Sierra Nevada (*Cooper*). Pacific coast.

Helix Mullani, Bld. and J. G. Cp.—Cœur d'Alêne mission, Bitter Root Mountains and River, Idaho (*Cooper*); Idaho (*Binney*).

Helix fidelis, Gray.—Large but very pale variety, Sumass Prairie, Fraser River (*Lord*). Pacific coast.

Helix Townsendiana, Lea—"Both slopes of the Bitter Root Mountains, from 2,200 to 5,000 feet high. Large variety at the base of the range to 4,800 feet; small variety in dry prairie at junction of Hell-Gate and Bitter Root Rivers" (*Cooper*). Sumass Prairie, Fraser River; small variety Fort Colville, summit of Rocky Mountains (*Lord*); east of Fort Colville, Washington Territory (*N. W. Bound. Surv.*). Pacific coast.

The small variety from northwest Idaho has been described as a new species by Mr. A. D. Brown under the name of *Helix ptychophora* (Journal de Conchologie, 1870), giving as its habitat Bitter Root Mountains and Nebraska. It is regarded as a variety only.

Helix pulchella, MÜLLER.

Camp 11:	Blue River Valley	16 specimens.
Camp 20:	West of Saguache	4 specimens.
Camp 21:	Los Pinos Indian Agency	65 specimens.
Camp 26:	Howardville, Baker's Park	50 specimens.
Camp F:	Rio La Plata	10 specimens.
North Park (*Barber*)		25 specimens.

"This American form (*minuta*) of the Old-World *pulchella*, Müll., has only lately been found west of the Rocky Mountains. I obtained an immature specimen near Truckee, in May. * * * Mr. Harford afterward found it common near Donner Lake, a few miles above Truckee; and Mr. Hemphill has also found them common near White Pine Mountains. Not having been found north of Canada, its circumpolar distribution, though asserted by Middendorf, is doubtful; he, like most authors, considering it identical with *pulchella*."—Dr. J. G. COOPER.

Helix Dupetit-Thouarsi, Desh.—Klamath Lake, Oregon (*Newberry*); Sumass Prairie (*Lord*). Pacific coast.

Helix tudiculata, Binn.—Truckee, Nevada (*Carlton*). Pacific coast.

SUCININÆ.

Succinea Nuttalliana, LEA.

Camp 9:	Hot Sulphur Springs	30 specimens.
Camp D:	Animas Valley	1 specimen.

Warm Springs, near Salt Lake, Utah (*Reid*); Snake River (*Nuttall*); Wright's Lake and Rhett's Lake, northeast California (*Newberry*). Pacific coast.

Succinea ovalis, GOULD.

Camp 10:	Mouth of Blue River	1 specimen.

Eastern States.

Succinea rusticana, GOULD.

Camp 9:	Hot Sulphur Springs	12 specimens.

Sumass Prairie, Fraser River (*Lord*); Rocky Mountains of Bitter Root Valley, 2,500 to 4,500 feet (*Cooper*); White Pine region, Nevada (*Hemphill*). Pacific coast.

These three species are hardly to be distinguished. I separated them as above after examination of shells in the Museum of Comparative Zoölogy, but they merge into one another indeterminately.

Succinea Hawkinsii, Baird.—East of Fort Colville, Washington Territory (*N. W. Bound. Survey*); Lake Osoyoos (*Lord*); British Columbia.

Succinea Sillimani, Bland.—Humboldt Lake, Nevada (*Silliman*). Pacific slope.

Succinea lineata, W. G. BINNEY.

Camp 20: 20 miles west of Saguache	8 specimens.
Camp D: Animas Valley	50 specimens.
Lakes, San Luis Valley	10 specimens.
Bank of Bear River (*Barber*)	1 specimen.

Northeast California to Nebraska and British Columbia (*Cooper*); Utah, Yellowstone River (*Smithsonian Catalogue*); Little Colorado, Arizona (*Palmer*); Este's Park, Colorado (*Carpenter*).

I should not quarrel with any one who should pronounce some of the smaller of my specimens to be *S. Stretchiana*, Bld. Yet, upon comparison with shells in the Museum of Comparative Zoölogy, I prefer to call them all by the above name. They include but four living snails among the whole number, the rest being dead shells. Mr. Barber's example is a fine one.

Succinea Stretchiana, Bland.—Little Valley, Washoe County, Nevada (*Stretch*). Pacific slope.

Succinea avara, White Pine, Nevada (*Binney*). Eastern North America.

If, as is indicated by the map appended to Mr. Binney's catalogue (Bull. M. C. Z., III, IX), the Central Province includes the valley of the Yellowstone as far east as its mouth, *Succinea Haydeni*, W. G. Binn., and *S. retusa*, Lea, must be considered to belong to our list, and several localities on the Yellowstone River can be added to the distribution of *S. lineata*, as well as to that of several mollusks in other families.

PHYSIDÆ.

Physa heterostropha, SAY.

Camp 9: Hot Sulphur Springs	100 specimens.
Camp 18: Springs east of Saguache	40 specimens.
Between the Animas and La Plata	5 specimens.

Its range from the Atlantic to the Pacific is well assured, it having been collected in nearly every State and Territory. These specimens show the greatest variation in point of size, shape, and color; yet, in the absence of other types, all seem referable to this species. The Grand River, which flows through Middle Park, contains no *Physæ* (or other mollusks) that I could discover; but at the Hot Springs, in a little lagoon filled at high water, large, clear, *ampullacea*-like shells were common. In the few yards of exposed outlet of the springs of hot sulphur-water from which the locality derives its name and celebrity, there occurred in the greatest profusion a blackish globose variety about one-fifth of an inch long. The temperature of this water was at some points as high as 100° F. In the basin of a still hotter spring close by, whose waters were saturated with chlorides of sodium and magnesium, hundreds of still smaller *Physæ* (see below) were floating about in mats, glued together by a tangle of confervoid vegetation and the depositions of the water. All of these seemed to have lost the apex of the spire by

erosion, "which is extremely liable to happen to shells living in water charged with alkaline salts other than lime." Yet quite as small and black were the examples from the cold, clear, abundant springs near Saguache, where there was seemingly nothing whatever to stunt their growth.

Physa Wolfiana, Lea.

In the Proceedings of the Philadelphia Academy for 1869, Mr. Isaac Lea described a species of *Physa* from "the Hot Sulphur Springs, Colorado," collected by Prof. J. W. Powell, which he named *Physa Wolfiana.* Inasmuch as my shells came from the exact and very limited station and locality (*vide* Observations, XIII, 67; Pl. XXI, fig. 20) as his types, I suppose I must have it; but as I cannot separate to my satisfaction those which resemble that shell as described and figured, from those which do not resemble it, I have remanded all to the foregoing species.

Physa Lordi, Baird.—British Columbia (*Lord*), replacing *P. heterostropha* on the higher ground toward the Rocky Mountains; east of Fort Colville, Washington Territory (*Northwestern Boundary Survey*). It is not unlikely that *P. Clarkei* and the two following species will prove identical with this, differing only in size and color. Here, as in *Limnea,* the shell is subject to such variation that it is precarious to predicate specific rank upon the shell alone, particularly if the specimens be few and localities isolated.

Physa ampullacea, Gould.—Oregon and Washington Territory (*Cooper*); Rhett's Lake, California, and Upper Klamath Lake, Oregon (*Newberry*).

Physa ancillaria, Say.—Ruby Valley, Nevada (*Simpson*).

Physa gyrina, Say.—Carson, Nevada (*Wheatley*); Nevada (*Simpson*). Missouri River.

Physa humerosa, Gould.—Colorado Desert, Pecos River (*Blake*).

Physa Grosvenorii, Lea.—Dayton, Nevada (*Wheatley*).

Physa parva, Lea.—Little Valley, Nevada (*Wheatley*).

Physa Hawnii, Lea.—White Pine, Nevada (*Hemphill*).

Physa Saffordii, Lea.—Fort Hall, Idaho, and Snake River Valley, Utah (*Reid*); Nevada and Eastern Idaho (*Hemphill*).

Physa virgata.—Gila River (*Gould*). Southern California.

Physa propinqua, Tryon.—White Pine, Nevada (*Hemphill*); Jordan Creek, southwest Idaho (*Gabb*).

Physa occidentalis, Tryon.—Fort Colville, Washington Territory (*Horn*); Warner's Valley, Oregon (*Gabb*); Truckee, Nevada (*Carlton*).

Physa Blandii, Tryon.—Truckee, Nevada (*Carlton*).

Physa malleata, Tryon.—Hell-Gate River, Montana, and Fandango Valley, a part of Goose Lake Valley, Oregon (*Gabb*).

Physa Nuttallii, Lea.—Lewis River, Idaho (*Nuttall*).

Physa Cooperi, Tryon.

Between the Animas and La Plata .... 5 specimens.

Also recorded from a spring in Crane Lake Valley, northeast California (*Gabb*). I do not feel quite sure of this determination, because of the immaturity of the specimens, and the fact that I do not have access to types; nor do I altogether trust in the validity of the species.

Bulinus hypnorum, Linnæus.

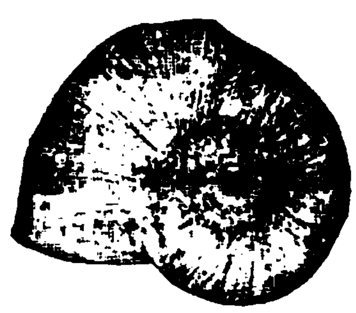
Camp 9–10: Grand River Valley .... 50 specimens.
Bear River (*Barber*) .... 5 specimens.

Recorded also from Hell-Gate River, Montana (*Cooper*); Utah; Malade River, Idaho (*Hemphill*); Washington Territory; Yellowstone River (*Smithsonian Catalogue*); British possessions (*Lord*) northward. Cosmopolitan.

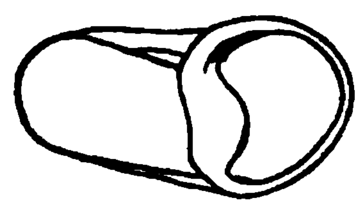
PLANORBINÆ.

Helisoma plexata, SP. NOV.

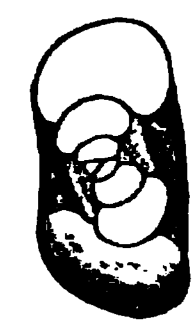
Shell a little larger than P. TRIVOLVIS, Say, *of irregular proportions, fragile; whorls 4–5, the inner 3–4 of the spire angulated and coiled in a plane, which is considerably inclined to the plane of the outer revolution in such a way that the carina of the third whorl rises into a sharp shoulder on the right side, and on the left side sinks underneath the overflowing last whorl, which takes on a sudden increase in old age. A similar, but less, change in the plane often occurs again in the fourth whorl, giving a very twisted appearance to the shell. Surface marked by irregularly-crowded, wavy, raised lines of growth. Umbilicus broad, exhibiting the well-rounded whorls to the apex. Aperture somewhat oblique, pretty regularly pyriform in outline, the vertical slightly exceeding the horizontal diameter, and embracing a considerable portion of the body whorl, well to one side of the median line. Peristome gently reflected, slightly thickened within, and fully lined with an opaque white deposit, which also forms a thick and well-defined callous connecting the ends. Color yellowish horn to reddish-brown (becoming almost black behind the aperture), most specimens abundantly banded and streaked with revolving lines of ochraceous red, and fine black threads.*



Spire.



Aperture.



Section at aperture showing change of plane in revolution.

Saint Mary's Lake, Antelope Park .... 25 specimens.

This species existed in countless numbers in the above-mentioned lake, which is a small sheet of water held among precipitous cliffs, that afford it no visible outlet. It seems to be merely a "sink" for the melted snow of the surrounding heights. All of the hundreds of individuals seen, possessed, in a more or less marked degree, the twisted appearance, resulting from the change of plane in the old age of the shell, which is their most striking character. How the species came, almost entirely alone, to inhabit this secluded lake is a problem, complicated by the fact that there probably is not another large *Planorbis* within fifty miles. That the wild fowl, abundant on the lake, brought the eggs clinging to their feet, may be a plausible explanation; but where did they bring them from, and when? The bottom of the lake is, for the most part, rough conglomerate rock, and it is in many places filled with heavy water-plants, which may account for the peculiarities of the shell.

The members of the family *Planorbidæ*, seem to be particularly subject to sudden and eccentric deviations from the normal form of the group. Many curious examples have been noticed. The genus *Valvata* seems also subject to similar deformities, which Prof. Alpheus Hyatt, of Cambridge, Mass., has been paying special attention to of late, in the

course of some paleontological investigations. Concerning this matter Professor Hyatt writes as follows, in a letter dated February 10, 1876:

"These variations have been studied only with reference to the shell, but the changes of form are so great in this external organ, that one naturally infers corresponding differences in the animals themselves. The principal papers heretofore published upon these interesting shells are but two in number: one by Hilgendorf, in the Monatsber. d. köngl. Preuss. Akad. d. Wissen., 1866, upon the fossil forms of *Planorbis multiformis;* and one by M. Piré, upon *Planorbis complanatus*, in the Annales de la Soc. Malacol. de Belgique for 1871. The recorded information is therefore scanty, and it would be a very important service to conchology and paleontology if every one who has met with abnormal or distorted forms, in the course of his collecting of land or fresh-water shells, would make public all the information he has in connection with those discoveries. Records of such experiences are extremely desirable.

"Both of the papers alluded to above are accompanied by figures, and show a very remarkable series of forms, which vary from the flat spire with equal umbilici, to those which are completely trochiform, and from these to specimens entirely unwound, like a wire corkscrew. I have myself studied attentively the Steinheim beds described by Hilgendorf, and can confirm his results so far as the extreme variations of form are concerned, though in other respects his paper is full of erroneous statements, especially with regard to the genetic connections and stratigraphical distribution of the varieties.

"I have also a very remarkable series of shells, probably belonging to *Valvata*, which I owe to the kindness of Prof. Edward S. Morse. They were collected by Prof. C. F. Hartt in marl laid dry by the drainage of Lawlor's Lake in Nova Scotia. These are equal to any described species in variation, some of them being actually unwound, with a perfectly cylindrical outline, to the mouth of the shell. What the governing peculiarities of the locality last named may have been at the time the marl was deposited, I cannot say, but the condition of the Steinheim Lake during the Tertiary period, and of the small ponds, described by M. Piré, resembles closely that of the localities described in your paper.

"The Steinheim Lake was evidently, as shown by Quenstedt and Fraas, an isolated sheet of water about a mile in diameter. The ponds of Magnée, according to M. Piré, are fed only by rain-water, but are never frozen and never dry.

"Not only, therefore, is the occurrence of these extreme variations exceptional, but they appear in localities presenting certain exceptional characteristics. These characteristics are well worth investigating, since it seems as if a direct correlation existed between the extreme variations of the shells, and some physical cause common to all the localities in which the distorted specimens have been found. That the variations are not distortions in the ordinary meaning of that word, can be readily understood by any one who has studied an extended series of them. The most aberrant of these varieties in Steinheim has descendants, which perpetuate its peculiarities for what must have been a considerable lapse of time, forming races of greater or less importance; and M. Piré inferred the same fact at Magnée, from dead shells found buried in the mud at the bottom of the cisterns. I have no doubt that the remust be a vast array of similar experiences awaiting any explorer of the isolated lakes and ponds of this country, and I hope your publication will open the way for many similar observations. In no other direction can we look for more light upon the mode of origin of new races and forms,

and the causes which lead to their production, than by the study of such isolated localities, where causes are reduced to their least complicated state, and results reach their maximum, so far as the observability and variety of the characteristics are concerned."

Helisoma trivolvis, SAY.

Pond between the Animas and La Plata	10 specimens.
San Luis Lakes	5 specimens.

There is a long list of recorded localities from all the Territories, as well as British America and the Pacific coast, so that it seems universally distributed over this continent.

The pond first alluded to was entirely isolated, and several acres in extent, resorted to by vast flocks of wild fowl, and inhabited by all sorts of fresh-water and amphibious life. The bottom was muddy, and nearly the whole expanse choked with luxurious vegetation.

All of the species, which were abundant, seem to belong to this species, although there are scarcely two alike. One resembles closely *Planorbis macrostomus*, Whiteaves; another is near *P. tumens*, Cpr.; a third variety might be identified as *P. glabratus*, Say, if that shell were dextral; yet, while all differ in development and in color, all agree in being very fragile, which may be owing partly to scarcity of lime in the water, and partly to the soft bottom; and in having a short vertical diameter, which peculiarity may have been acquired by them from the necessities of their habitat, since snails having shells with small breadth of beam could most advantageously pass between the stalks of standing water-plants which everywhere crowd the pond. This species is an inhabitant of the United States generally.

Helisoma ammon, Gld.—Colorado Desert (*Blake*); Klamath Lake, Oregon, and Rhett Lake, California (*Newberry*); east of Fort Colville, Washington Territory (*Northwestern Boundary Survey*). Pacific slope.

Helisoma Traskei, Lea, is probably a synonym of the above. California.

Helisoma corpulentus, Say.—Oregon and Washington Territory (*United States Exploring Expedition*); Lake Osoyoos, Washington Territory (*Marsh*); British Columbia (*Lord*); Okanigan River, Washington Territory (*Cooper*); Pacific Coast and Guatemala. It seems doubtful whether this is not a synonym of *H. trivolvis*.

Planorbis oregonensis, Tryon.—Pueblo Valley, on the boundary between Oregon and Nevada, "from a thermal spring, water above blood-heat" (*Gabb*).

Planorbis subcrenatus, Cpr.—Oregon (*Nuttall*); Washoe, Nevada (*Newcomb*); Sumass Prairie, British Columbia (*Lord*). California.

Planorbis Hornii, Tryon.—Utah (*Surv. W. of 100th M.*); Truckee River, Nevada (*Carlton*).

Planorbis gracilentus, Gld.—Colorado Desert (*Webb*). This seems to be a northern form of *P. Liebmanni*, Dunker.

Gyraulus parvus, SAY.

Camp 9: Hot Sulphur Springs	1 specimen.
Arkansas River, ten miles below Granite	5 specimens.
Between Rio Animas and Rio La Plata	2 specimens.
Saint Mary's Lake, Antelope Park	50 specimens.
North Park (*Barber*)	6 specimens.

It occurs also in Hell-Gate River, Montana (*Cooper*); Cœur d'Alêne Lake, Montana (*Hemphill*); Ruby Valley, Nevada (*Simpson*); and along the Yellowstone (*Smiths. Catal.*). Eastern States.

Gyraulus vermicularis, Gld.—Truckee, Nevada, altitude 5,866 feet, rare; Dalles, Oregon (*Cooper*). Santa Cruz northward.

POMPHOLIGINÆ.

Pompholyx effusa, Lea.—Near White Pine, Nevada (*Hemphill*); northeastern California (*Newberry*). Sacramento Valley.

Carinifex Newberryi, Lea.—Klamath Lake, Oregon (*Newberry*). California.

Vorticifex Tryoni, Meek.—Fossil in Tertiaries of Nevada (*King*).

ANCYLINÆ.

? Ancylus parallelus, HALDEMAN.

North Park (*Barber*) .... 4 specimens.

Among the shells brought home by Mr. Barber were four apparently full-grown specimens, and one young one, of an *Ancylus*, none of which contained the animal. While closely resembling the figure of *A. caurinus*, Cooper, given on page 144 of Part II, of Binney and Bland's Land and Fresh-Water Shells of North America, careful comparison with the large series in the Museum of Comparative Zoölogy failed to establish any great difference between them and *A. parallelus*. As, however, this latter species has not been found hitherto, out of New England, it seems only proper to look upon the apparent identity of the Colorado and eastern shells, with caution. A slight difference in the angle of the sides *en profile* may, perhaps, be noticeable between them.

Ancylus Newberryi, Lea.—Klamath Lake, Oregon (*Newberry*).

Ancylus kootaniensis, Baird.—Rivers Kootanie and Spokane (*Lord*).

Ancylus patelloides, Lea.—Spokane River, Washington Territory, [approaching *A. kootaniensis*] (*Hemphill*). California.

Acroloxus Nuttallii, Hald.—Oregon (*Nuttall*); lower part of Snake River, Washington Territory (*Hemphill*). California.

LIMNÆIDÆ.

Limnea stagnalis, LINNÆUS.

Between the Animas and La Plata.................. 2 specimens.

Fraser River, typical, fine, and abundant (*Lord*); east of Fort Colville (*Northwest Boundary Survey*); Rhett's Lake, California (*Newberry*); Ruby Valley, Nevada, and southern Utah (*Simpson*). Circumpolar.

Limnea sumassi, BAIRD.

Between the Animas and La Plata.................... 1 specimen.

East of Fort Colville, Washington Territory (*Northwest Boundary Survey*); Sumass Prairie (*Lord*).

Limnea Haydeni, W. G. B.—Yellowstone and Big Sioux Rivers (*Hayden*); Ruby Valley, Nevada (*Simpson*).

Limnea——?

Camp 30: Rio Grande, above del Norte.............. 50 specimens.

REMARKS.—"Near *L. Rowellii*, Tryon."—Dr. JAS. LEWIS, *in letter*.

Limnea palustris, MÜLLER.

Between the Animas and La Plata .... 2 specimens.

Columbia River (*Nuttall*); Klamath Lake and Sumner Lake, Oregon; Rhett's Lake and Wright's Lake, California (*Newberry*); Hell-Gate River and Missouri River above Falls (*Cooper*). Circumpolar.

Limnea Nuttalliana, LEA.

Between Animas and La Plata Rivers .... 75 specimens.

REMARKS.—Often considered a synonym of *L. palustris*, with which, in the West, it seems to be co-extensive.

Limnea desidiosa, SAY.

Camp 9: Hot Sulphur Springs .... 10 specimens.
Camp 11: Blue River Valley .... 10 specimens.

Lake Osoyoos, Washington Territory (*Lord*); Missouri River above the Falls (*Cooper*); Yellowstone River (*Hayden*). Eastern United States and Mississippi Valley. This shell is called *Limnea obrussa* in many western lists.

Limnea catascopium, Say.—New England to Lewis [Snake] River, and through British America (*Binney*); Lake Utah (*Burton*); Idaho (?).

Limnea Binneyi, Tryon.—Hell-Gate River, Montana (*Binney*).

Limnea emarginata, Say.—New England to Washington Territory (*Auct*).

Limnea bulimoides, Lea.—Oregon (*Nuttall; Hayden*).

Limnea Traski, TRYON.

Colorado .... 6 specimens.

A Californian species.

Limnea humilis, SAY.

Camp 17: San Luis Valley .... 2 specimens.
Camp 26: Howardville, Baker's Park .... 1 specimen.

Hell-Gate River, Montana (*Cooper*). All over the continent.

? Limnea ferruginea, HALDEMAN.

Between the Animas and La Plata .... 2 specimens.

Oregon (*Nuttall*). "If not *L. ferruginea*, it may be new."—Dr. JAS. LEWIS, *in letter*.

Class CONCHIFERA.

Order DIMYARIA.

CORBICULADÆ.

Sphærium striatinum, Lamarck.—Hell Gate River and Missouri River above the Falls (*Cooper*); Humboldt River, Nevada (*Hepburn*). Eastern North America.

Sphærium occidentale, Prime.—Hell-Gate River (*Cooper*). Northern States and Canada.

Sphærium dentatum, Hald.—Oregon (*Nuttall*).

Sphærium patella, Gould.—Walla-Walla, Oregon (*U. S. Expl. Exped.*).
Sphærium lenticula, Gld.—Lake Tahoe, Klamath and Carson Rivers, Cal. (*Cooper*).
Sphærium tumidum, Baird.—Sumass Prairie, Fraser River (*Lord*).
Sphærium spokani, Baird.—Spokane and Kootanie Rivers (*Lord*; *Hemphill*).
Sphærium tenue, Prime.—I am confident that I secured this species (one specimen) at the Rio La Plata. It has been recorded, I think, from Montana and another northern locality. It is a boreal species.

Pisidium abditum, HALDEMAN.

Camp 9: Hot Springs	30 specimens.
Camp D: Animas Valley	1 specimen.
Saint Mary's Lake, Antelope Park	1 specimen.

Raft River, near Fort Hall, Idaho (*Reia*); Truckee River (*Carlton*). All over the continent.

My specimens vary greatly in color, but seem to be all referable to this widely-distributed species. Many are about half-grown.
Pisidium compressum, Prime.—White Pine, Nevada; Owen's River, California (*Hemphill*). Northern States and Canada.
Pisidium occidentale, Newc.—Truckee River, Nevada (*Carlton*). California.
Pisidium ultramontanum, Prime.—Canoe Creek, Pitt River, California (*Cooper*).

UNIONIDÆ.

Unio luteolus, Lam.—Missouri River, above the Falls (*Cooper*). United States generally.
Margaritana margaritifera, Linn.—Missouri River above the Falls; Spokane River below Cœur d'Alêne Lake (*Cooper*); Salt Lake, Utah, or Fort Hall, Idaho (*Reid*); Truckee River, Nevada (*Carlton*). Cosmopolitan. This Mollusk is eaten by the Indians east of the Cascade Mountains.
Anodonta angulata, Lea.—Idaho, Montana (*Cooper*); Columbia River (*Lord.*) Considered at most only a variety of the foregoing.
Anodonta oregonensis, Lea.—Abundant east and west of the Cascades (*Lord*); Montana (*Cooper*).
Anodonta Nuttalliana, Lea.—Idaho (*Cooper*).
Anodonta whalamatensis, Lea.—Idaho, to British Columbia (*Cooper*).

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TOPOGRAPHY AND GEOGRAPHY.

REPORTS

OF

HENRY GANNETT, S. B. LADD, AND A. D. WILSON.

GEOGRAPHICAL REPORT OF HENRY GANNETT, M. E., TOPOGRAPHER DIRECTING MIDDLE DIVISION.

INTRODUCTORY LETTER.

SIR: I have the honor to submit to you herewith my report on the geographical work of the middle division of the survey during the season of 1874.

The party in my charge was composed as follows: Dr. A. C. Peale, geologist; Fred. D. Owen, assistant topographer; Frank Kellogg and Arch. R. Balloch, general assistants, with two packers and a cook.

The party left Denver on July 21, and proceeded to the field of work via Fairplay, Mosquito Pass, and Tennessee Pass, returning by the southern route, via Cochetopa Pass, San Luis Valley, Poncho Pass, and Cañon City, reaching Denver November 10.

The area worked is five thousand three hundred square miles, in doing which eighty-six stations were occupied, or an average of one in every 8 miles.

I would here express my thanks to Mr. H. F. Bond, Indian agent at the Los Pinos agency, for assistance rendered by him during the season.

Very respectfully, your obedient servant,

HENRY GANNETT.

Dr. F. V. HAYDEN,
United States Geologist.

CHAPTER I.

The district assigned to the middle division for the field season of 1874 was bounded as follows: Commencing at the intersection of the Grand River with the meridian of 109° 30′, the north line follows the Grand up to the mouth of the Eagle River; thence the Eagle River to its intersection with the parallel of 39° 15′; thence west, along this parallel, to the meridian of 107°; south on this meridian to the parallel of 38° 20′; west on this parallel to the meridian of 109° 30′, and north on this meridian to its intersection with the Grand River. The total area of this district is seven thousand five hundred square miles. Of this area the party in my charge has worked all of the country lying between the Grand and Gunnison Rivers, the strip lying between the parallel of 39° 15′ and the Eagle River, and a small area south of the Gunnison River, between the one hundred and seventh and one hundred and eighth meridians.

PREVIOUS EXPLORATIONS IN THE DISTRICT UNDER CONSIDERATION.

With the exception of a little work done along the borders, this country was as little known as any part of the Western Territories. No map, representing even the most general features, was in existence.

In 1845, Frémont, at that time a lieutenant in the Corps of Topographical Engineers, skirted the northern border for a short distance. He came up the Arkansas River, crossed the main divide at Tennessee Pass, and traveled down Eagle River as far as the mouth of *f* creek. Here he crossed the river and took the trail over to White River, which stream he followed down some distance, then crossed the country to the Green River, thence to Salt Lake City. He was in the country in which I worked during last season, only while on the Eagle River for a distance of about thirty miles.

In the autumn of 1853, Captain Gunnison, with a large force of soldiers and civilian employés, including topographers and a geologist, and a large wagon-train, came into this country by way of San Luis Valley, Cochetopa Pass, and Cochetopa Creek. From the mouth of Cochetopa Creek his course was down the Gunnison as far as the mouth of White Earth Creek, sixteen miles, within which distance he was obliged to cross the river several times. At the mouth of White Earth Creek he was obliged to leave the Gunnison and cross the rolling, broken country south of it, in a southwesterly direction, to Lake Fork, which he crossed with considerable difficulty several miles above its mouth. He then continued down its west bank nearly to the Gunnison, where he wound around the side of the mesa to the valley of Mountain Creek. He traveled up the valley of this creek, in a direction nearly

south, for several miles, then left it, gaining the summit of the plateau. On this summit he traveled in a direction generally west, crossing several streams, until he reached a branch of Cebolla Creek. He traveled down this branch and the main creek to a point only one mile from its mouth, where the Gunnison is in a tremendous cañon. There he left Cebolla Creek and crossed the ridge to Cedar Creek, a branch of the Uncompahgre River. Thence he followed Cedar Creek and the Uncompahgre to the Gunnison River. He forded the Gunnison at the mouth of Roubideau's Creek. Thence his course followed a low, trough-like depression in the valley near the mouth of the Gunnison to the Grand River, which he forded about five miles above the mouth of the Gunnison. Below this point his route followed the course of the Grand quite closely for a long distance below what he supposed to be the mouth of the Dolores, finally crossing to the Green, and thence to the Sevier, whence it goes nearly north to Salt Lake City. The topographical work done by this expedition consists of a narrow belt on each side of their line of travel. The general course of the Gunnison, except in the great cañon, was mapped.

A few months later, Frémont passed over the same route, on his way to California.

In the summer and fall of 1873, Lieutenant Ruffner, United States Engineer Corps, had a party within this district, under the immediate direction of civilian assistant H. G. Prout. This party surveyed the principal part of Ohio Creek, and the head of Anthracite Creek, a branch of the North Fork of the Gunnison River—in all, perhaps, two hundred square miles. His map, of which this area forms but a small portion, was published in the spring of 1874. In Mr. Prout's report, which accompanies the maps, he gives certain names to some of the prominent mountain-peaks in this area. These names would be placed on our maps, were it possible to identify the peaks on which they have been bestowed, but neither from his report nor from his map can the names be located.

GEOGRAPHY OF THE DISTRICT.

In this report, I shall take up the whole country west of the Sawatch range, over which I have worked during the two seasons of 1873 and 1874, in order to consider the Elk Mountains and their spurs as a whole, even at the risk of repeating some of my report on the field-work of 1873.

West of the Great Sawatch range, the county is drained by the two rivers, the Grand and the Gunnison. The Gunnison is the largest and most important branch of the Grand, while the Grand, by its union with the Green, gives rise to the Rio Colorado, which drains nearly all of the southwestern part of the United States.

The principal branches of these rivers are: of the Grand, from the south, Eagle River, Roaring Fork, Divide Creek, and Plateau Creek; of the Gunnison River, from the north, Taylor River, Slate River, Ohio Creek, Smith's Fork, and the North Fork of the Gunnison, and from the south, Texas Creek, Cochetopa Creek, Lake Fork, (or Rio de la Laguna of the Spaniards,) Cebolla Creek, and the Uncompahgre River.

The country between these two large streams, the Grand and Gunnison, consists, in the eastern part, of the system of mountains known as the Elk Mountains, with its spurs, which, at its western extremity, falls into plateau, considerably broken down by denudation. The Elk Mountains, with their spurs, occupy the whole area between the Eagle River and the portion of the Grand River between the mouths of the Eagle and Roaring Fork on the north, and the Gunnison from its head to the

mouth of its North Fork on the south and west. The whole area covered by this system is about three thousand two hundred square miles. This estimate covers not only the high mountain region, but also all the spurs directly connected with the range, thus including much rolling and valley country.

The principal part of this mountain system is in the form of a series of parallel ranges connected transversely by low saddles, and having a direction about north 30° west and south 30° east, or essentially the same direction as the Sawatch and Park ranges and other ranges in Colorado. The most important of these ranges, both in height and continuity, is the most eastern, the one which is terminated on the north by Sopris' Peak, and includes Capitol Peak, Snowmass Mountain, Castle Peak, and others of the principal peaks of the system. This range joins the Sawatch range in a heavy, broad, and comparatively low ridge, in latitude 38° 45′.

Farther west, the parallel ranges are not as continuous, or as high, but all have a uniform direction, until we reach the western part of the system. In about the longitude of the head of Ohio Creek, *i. e*, longitude 107° 5′, the character of the grouping changes, and the mountains are in isolated groups, irregularly disposed. But here, as farther east, the drainage still has the same direction, slightly west of north and east of south, as is the case with Ohio Creek, Anthracite Creek, and many others, as is seen by a glance at the map.

The drainage of the Elk Mountains toward the north into the Grand is carried entirely by Roaring Fork and its branches; to the south by the Gunnison and its branches from the north above its North Fork; and on the west by the North Fork of the Gunnison.

Frying-Pan Creek, one of the largest branches of Roaring Fork, is in a very narrow valley, or close cañon throughout its course, from the Sawatch range to its mouth. It is bordered on each side by broad, high ridges, reaching to the timber-line or above. The same broad, massive character appertains to the ridges separating all the branches, which unite to form Roaring Fork, as far around toward the west as Castle Creek. Here we reach the principal range of the Elk Mountains, and the character of the mountain-forms changes materially. The broad, massive ridges give way to sharp, conical peaks, ragged, serrated ridges, pinnacles, and spires. They increase in elevation from 11,000 or 12,000 feet to 13,000 or 14,000. The mountains present great diversity of colors, some being of light-gray trachyte, others of red, maroon, and brown sandstone.

The principal range of this mountain system separates Roaring Fork from Rock Creek. It is a very well defined range as far south as the divide, and a few miles beyond. Farther south it diminishes in elevation and loses its distinctive character, in a number of spurs, separating branches of the Gunnison. Of this range, Sopris Peak is the most northern summit. It rises abruptly from the broad, flat valley of Roaring Fork to a height of 7,000 feet above it. It is a very massive mountain, covering, with its broad spurs, an enormous extent of country, and standing alone, as it does, is a very conspicuous and well-known landmark in all the surrounding country.

South of Sopris peak, the range falls to a height little above the limit of timber; this comparatively low ridge extends, with little change in elevation, to Capitol Mountain, one of the crowning summits of the range, whose gray, prism-shaped top and precipitous sides forbid access. A ragged spur running from Capitol Mountain northeastward separates Capitol and Snowmass Creeks. It bears, near its end, a high summit,

which has been named Mount Daly, in honor of the gentleman who is now president of the American Geographical Society. Two and three-tenths miles farther south on the main ridge is the summit which has been named Snowmass Mount. This also is one of the highest summits in the system, being but slightly inferior to Capitol Mountain in elevation. It is a station in the primary triangulation. It has received its name from an immense field of snow on its eastern face. This snow-field, in August, which is the month when there is the least snow in the mountains, had an area of fully five square miles. Probably this is the nearest approach to a glacier in the Rocky Mountains. These mountains, Sopris, Capitol, Daly, and Snowmass, being of eruptive rocks, are extremely rugged and precipitous.

Following the ridge farther south, it falls to an elevation of but 12,500 feet, which it holds for about six miles; then, on a sharp angle in the ridge, rises Maroon Mountain. This peak is so named from its peculiar color, that of the sandstones of which it is composed. It is one of the highest peaks in the system, and its summit is nearly, if not quite, inaccessible. On the north and south it presents walls almost vertical for 2,000 feet; on the west it is full as steep for 3,000 feet, and on the east a sharp, comb-like ridge runs down from its summit, forming the commencement of a long, heavy ridge, which separates two large branches of Roaring Fork, Snowmass Creek on the west and Maroon Creek on the east. This ridge has a direction nearly north, and for many miles its crest is above timber-line, and it has several summits above 13,500 feet.

The main ridge, from Maroon Mountain, turns west for a few miles, with two quite high summits on it in this part of its course, then turns south and suddenly falls considerably at the head of Maroon Creek, sending off a heavy spur separating the two branches of Maroon Creek. The highest point of this spur is near its end. It has been named Pyramid Peak, from its peculiar shape. It is a first-class peak, reaching nearly 14,000 feet.

Farther down the main ridge, another spur with a sharp, ragged crest, separates Maroon Creek from the next branch of Roaring Fork, known as Castle Creek. Castle Peak, from which this creek derives its name, is the highest peak in the Elk Mountains. It stands on the dividing ridge, between the heads of two branches of Castle Creek. It has a conical summit, from which the main ridge runs south, in a succession of high, needle-like points, which rise several hundred feet above the ridge, gradually decreasing in altitude as they recede from the main peak. The summit is well-nigh inaccessible, the only way to reach it being up a crevice on the south side. Its color is dark brown. A high, sharp ridge, separating the two branches of Castle Creek, runs north-eastward from this peak. Summits on this spur reach nearly 14,000 feet.

From Castle Peak this range runs generally about southeast for several miles, bearing a number of summits of second-rate importance upon it, to the junction with the Elk divide, as I call the ridge separating the waters flowing into the Gunnison from those flowing into the Grand. South of this divide, the most important peak, perhaps, is the one named Italian peak, which stands at the extreme head of the Gunnison River. It was so named from the singular and beautiful grouping of colors on its surface, produced by the red rocks, white snow-fields, and green patches of vegetation.

South of Italian Peak, this range loses, in great part, its distinctive character, has a less elevation, and becomes a mass of low, heavy spurs.

Across these heavy spurs the Gunnison makes its way, cutting a deep cañon. On the south side of the river, at the head of the cañon, stands alone, a conical peak called Park Cone. This peak ends this range. Farther south a range of low hills connects with the range of the Continental water-shed. The branches of East and Slate Rivers are separated by broad ridges, rising but slightly above timber-line. Around their heads, however, separating them from the headwaters of Roaring Fork and Rock Creek, is a high, ragged ridge, set with lofty peaks, but broken by low saddles. At the head of Teocalli Creek is a high summit, known as White Rock Mountain, from the white, volcanic rock with which it is capped. Between White Rock Mountain and Castle Peak there are several very high summits, none of them, however, exceeding 13,500 feet in altitude.

South of White Rock Mountain, on the ridge separating Teocalli Creek from Dyke Creek, is a peak known as the Teocalli from its resemblance to the teocallis of the Aztecs. The strata composing this mountain are nearly horizontal, and are so broken as to form a series of steps from the base to the summit, a giant's stairway. The color of this mountain is a dark-brown.

On the north side of White Rock Creek is a spur separating it from the head of East River, on which are a number of high summits; also, at the extreme head of East River there is a high peak known as Bellevue.

The ridge or spur separating East River from Slate consists of three isolated mountains, separated from one another by low saddles. The northern one is known as Cinnamon Mountain, the middle one as Gothic Mountain, from the spires and pinnacles in bas-relief upon its eastern face, and the southern one as Crested Butte. The latter peak stands entirely alone, in the angle of the two streams, and rises 3,000 feet above the saddle north of it. This latter ridge is a part of a second range, similar in direction to the eastern. Tracing it north of Slate Mountain, it rounds the extreme head of Rock Creek by turning to the westward for three miles. There it joins an enormous mountain mass known as Treasury Mountain. In the south end of this mountain are the Elk Mountain mines, and the name of the mountain is connected therewith. This mountain extends, in a solid mass, in an east and west direction five miles, and north and south three miles, to the junction of Rock Creek with branch *b*. Between the mouths of creek *a* and *b*, Rock Creek is in close, heavy cañon, cutting its way through this mass. On the east side of Rock Creek, this mass, though still continuous, is more cut up by streams, and shows several high summits, with considerable fall in the saddles. It connects, by a very high ridge, with the eastern range. Its northern end is just west of Sopris peak, where a large branch enters Rock Creek from the south.

The third range commences west of Sopris Peak, on the west side of Rock Creek, in a ridge slightly above timber-line, which separates Rock Creek from the upper valley of the North Fork of the Gunnison. This ridge turns to the eastward, and crosses Rock Creek just above the mouth of the creek, leaving only a comparatively low saddle, whose top is about 2,000 feet above Rock Creek. This saddle is several miles long, and terminates suddenly in an immense mass of eruptive mountains, of which station 33 is a summit. There are a number of peaks in this mass, of heights from 12,500 to 12,800 feet. Some of the slopes in this group are terrific. The west side of this mass rises straight up from the plateau bordering North Fork for 2,500 feet, at an angle of 65°. At the head of Slate River is the highest peak in this range. It has a

prism-shaped summit, very similar to that of Capitol Mountain. Its elevation is 12,891 feet. There are several summits near it, both in position and elevation.

The next peak of importance in this range is station 32. This mountain stands slightly detached from the range, extending into and partly across the valley of Anthracite Creek, which takes a wide detour to get around it. It is composed of brownish-red, highly metamorphosed slates. There are three summits, of which the central one is the highest.

Farther down toward the south the range is very much diversified, now high, now low, but nowhere lower than 11,000 feet. It ends west of Crested Butte, in an isolated group of mountains, of an elevation of about 12,500 feet. South of this group there are two bits of sloping mesa, and then the valley of the Gunnison.

West of this range the mountains decrease in elevation, and occur in isolated groups. Between Anthracite and Coal Creeks there is a short range, consisting of two ridges, connected by a low saddle, of about 10,000 feet in elevation. These ridges contain several summits, ranging in height from 12,000 to 12,600 feet. In the angle of Anthracite Creek, and connected with the northern end of the range mentioned above, is a solitary peak, known to the prospectors as Mount Marcellina. Upon its precipitous southern face are, in bas-relief, Gothic spires, precisely as on the eastern face of Gothic Mountain.

Joining this range near the saddle, in the middle of its length, is quite a heavy group of mountains. It sweeps quite around the head of Ohio Creek, and contains many high peaks, several reaching nearly 13,000 feet. This group, in turn, is joined, by a low saddle, to a group which heads Coal Creek, of which 8–34 is the highest summit.

From station 34 to stations 38 and 39 runs a well-defined ridge, having an east and west direction. It connects with the last-mentioned group by a very low ridge, not exceeding 9,400 feet. This ridge ends the system, and with it the Rocky Mountains in this latitude. Westward, to the Wahsatch range in Utah, stretches a system of enormous plateaus, in which are cut the cañons of the Grand, Green, and Colorado Rivers.

Rising on the north from the valley of the Gunnison River and its North Fork, was originally a great plateau. Its limits were, on the west, about in longitude 108° 15′; on the south in latitude 38° 45′. It extended east nearly or quite to the Elk Mountains, and north to the Grand River. Its elevation, in its eastern part, is about 11,200 feet, an elevation still held by a few isolated points of trachyte. The elevations of a few points on its surface will give an idea of the direction and amount of its slope.

	Latitude.		Longitude.		Elevation.
	°	′	°	′	*Feet.*
Station 44	39	3	107	41	11,12[illegible]
Station 43	39	2	107	40	11,134
8-39	39	1	107	40	11,096
Station 42 (not the original surface)	39	0	107	45	10,682
Station 45	39	5	107	50	10,954
North Mam	39	23	107	51	10,973
South Mam	39	22	107	51	10,[illegible]
23-45	39	23	107	55	10,823
24-45	39	23	107	57	10,623
4-39	39	4	107	56	10,900
North end of plateau, (station 54)	39	6	108	13	9,800
South end of plateau, (station 59)	38	53	108	10	9,733

As will be seen, the direction of the slope is from the east toward the west, and is tolerably uniform, being about 50 feet to the mile.

The original basalt capping of the plateau has been in great part removed by denudation, appearing only in points and ridges, here and there, except in the western part, where a large area, of 75 square miles, preserves the original surface, and is as level as a floor.

This plateau has been cut in two pieces by a large creek, an affluent of the Grand River, which I have named Plateau Creek. It has cut out for itself a very broad valley, of a depth, in its deepest part, of 5,000 feet below the level of the plateau. With the aid of the Grand River on the north, it has cut down the western extension of the part of the plateau north of its valley to a range of low mountains. They are extremely rugged and precipitous, of elevations from 7,000 to 10,000 feet.

The Grand River has its head in the eastern part of Middle Park, across which it flows, receiving, on its way, several large branches. It cuts its way through the Park range on the western side of Middle Park in a very heavy cañon. In latitude 39° 39′, longitude 107° 3′, it receives the waters of one of its largest tributaries, the Eagle River. This stream heads in Tennessee Pass, and the mountains of the Park and Sawatch ranges. In that neighborhood, near its head, it flows through broad and beautiful meadows, which would be valuable for agricultural purposes and for stock-raising, but the elevation, over 9,000 feet, is too great for the former, and also for the latter, except during the summer.

The river receives, in these meadows, a large branch from the east, and, in the cañon, at the foot of these meadows, a large branch from the southwest and another from the east, by which its volume is very much increased. The branch from the southwest heads under Homestake Peak, so named from the Homestake mine, which is situated at timber-line on its southeastern slope.

Eagle River, below these meadows, is in close, high cañon for about five miles, emerging therefrom at the mouth of Roche Moutonnée Creek, into a narrow valley, inclosed by high, precipitous walls. The spur from the continental divide, of which the Mountain of the Holy Cross is the most northern as well as the highest peak, gives rise on the east and north to branches of the Eagle River, and on the west to Frying Pan Creek, a large branch of Roaring Fork. From this mountain mass, the spurs separating branches of the Eagle River have a broad, plateau-like character, sloping at a low angle, the ends forming the west wall of the cañon, and of the narrow valley below. These branches of the Eagle River are all in close cañon.

Below the mouth of Roche Moutonnée Creek, the river remains in a narrow valley as far down as the mouth of the Piney Creek, a branch from the east, nearly as large as the Eagle River itself. Below the mouth of this stream the valley broadens to nearly two miles in width; but this is mainly bench-land, with a gravelly soil, covered with sage, and can be of use only when irrigated. There is sufficient bunch-grass to afford indifferent grazing. The hills rise abruptly from this valley, and then extend back in long ridges to the mountain mass spoken of above.

The course of the river commenced to change near the mouth of Roche Moutonnée Creek, from north toward west, and at the foot of this valley, that is, near the mouth of *f* creek, has a course nearly west. Here it enters a cañon, which extends as far as station 7, where it ends abruptly, and the river flows through a broad valley, which extends nearly to its mouth, and far up *g* creek. This valley, like that above, is covered

mainly with sage, but, if irrigated, might prove productive. The soil, however, contains some alkali. *g* creek has a broad and fertile bottom. Between these two valleys, the country consists of rolling hills, covered with excellent grass.

From the mouth of *h* creek to its mouth, the Eagle River is in close cañon, and the junction of the rivers is in this cañon, which extends down the Grand to the mouth of Roaring Fork, with little intervals of valley. Its height is greatest fifteen miles below the mouth of the Eagle River, where it reaches 9,400 feet. This cañon is cut in a rolling table-land, of an average elevation of 9,000 feet, which separates the water of Eagle River from that flowing into Roaring Fork. It is well watered, sparsely timbered with quaking aspen, with plenty of excellent grass. It is too exposed and the elevation is too great for a winter range for stock, but for a summer range it is excellent.

The divide between the waters of the Eagle and Grand Rivers on the north, and Frying Pan Creek on the south, consists of a broad, flat-topped ridge, whose summit is slightly above timber-line. It joins the Sawatch range near the Mountain of the Holy Cross. Thence it has a course nearly west to Roaring Fork.

Roaring Fork takes all of the Grand River drainage on the northern slopes of the Elk Mountains, and the western slopes of the Sawatch range, north of the Elk divide. Its branches, without an exception of any consequence, head among the high peaks above the limits of timber, and most of them have their entire courses in the mountains. The lower course of Roaring Fork, that is, below the mouth of Castle Creek, is in a valley gradually increasing in width till it reaches its greatest width at the mouth of Rock Creek, where it is fully four miles wide. The bottom-land, as almost everywhere in the Territory, is excellent, and is unusually broad, but liable to sudden overflows from the melting of snows in the mountains.

Grand River, below the mouth of Roaring Fork, is in a narrow valley, with very high hills on each side, (rising abruptly,) for about three miles. Then it enters a close cañon, in which it is for twelve miles, when it issues from this cañon into a broad valley, east of the North Mam plateau, as I call the portion of plateau between Plateau Creek and the Grand River. The country south of this cañon of the Grand, and west of Roaring Fork, consists of high, rolling hills, covered with a heavy growth of cottonwoods. The elevation of summits in this mass of hills exceeds 10,000 feet.

The broad valley, alluded to above, extends down the Grand to the North Mam plateau, north of the river to a considerable distance, and south of it ten miles, speaking generally. Within this valley the Grand receives three branches of considerable size. The largest of these, which I have named Divide Creek, comes into the Grand just west of station 22.

The principal, almost the sole, production of this valley is sage. There is no grass, except in the stream bottoms. The soil is extremely poor. The hills farther south, which rise to the Gunnison and Grand divide, are covered densely with scrub-oak and smaller bushes, with some quaking aspen.

In passing the North Mam plateau and the Plateau range, the valley of the Grand is very much contracted, averaging not more than five miles in width. In this part of its course, the river is very sluggish and winding, with numerous bayous and islands.

Opposite the North Mam plateau, on the north side of the river, the country consists of a rolling plateau, extending as far to the north and

west as the eye can reach. The cliffs on the south edge of this plateau are perpendicular, and even in places overhanging, and the tops projecting, so that, at noon in August, they cast a shadow on the vertical wall beneath.

Below the Plateau range, the valley widens immensely. This valley is not more inviting than the one above the North Mam plateau.

In latitude 39° .08′, longitude 108° .19′ the Grand is crossed by the crest of a range of hog-backs. This crest has a general direction slightly west of north and east of south. The dip is toward the east, and is slight, and as the Grand does not cross this range in a direction contrary to that of the dip, but obliquely to it, the cañon which it cuts is very long, being about 15 miles. It increases in depth very gradually, until, at the lower end, it is about 1,800 feet. The western edge of this line of hog-backs is nearly vertical, and the exit of the river from the cañon is very abrupt. The surface of this hog-back is very much broken and cut by side-cañons.

Plateau Creek heads in the eastern part of the plateau, and about midway between the Grand and Gunnison Rivers. It flows first northwest, down the slope of the plateau, cutting deeper and deeper. At station 49 its course changes to west, and it holds this course very constantly to its mouth, in the middle of the Hog-back Cañon. This plateau has an enormous amount of drainage. Near its top the valleys are broad, flat, and marshy, with numerous small lakes or ponds. The best land in the district for agricultural and stock purposes, is that on and near the tops of the high mesas; but the great elevation precludes their use for these purposes.

Plateau Creek drains the whole of the northern slopes of the main plateau and the southern slopes of the North Mam plateau. All the streams flowing to it from the main plateau have a course nearly due north, forming a very regular system of drainage. The valley of this stream is, throughout the greater part of its course, quite wide, with, in places, enormous extents of bench-land between its branches.

At the foot of Hog-back Cañon the Grand emerges into a broad valley in which it meets the Gunnison. This valley is of enormous extent, stretching far down the Grand, even beyond the Sierra la Sal and up the Gunnison ten miles above the mouth of the Uncompahgre River, and up the Uncompahgre for at least forty miles. Its width, on the Grand, below the mouth of the Gunnison, is about ten miles. It is bordered on the northeast, for some distance, by the range of hog-backs mentioned above; on the southwest, by a plateau lower than that described above and of a different character. The Grand hugs closely the edge of this plateau. The river-bottom of the Grand is upward of a mile in width, well timbered with cottonwoods, and very fertile. The rest of the valley is bench-land, elevated about 100 feet above the river, at the edge, rising very gradually toward the range of hog-backs. The soil is gravelly, with much alkali, and produces only greasewood and sage.

The part of this valley included between the Grand, the Gunnison, and the west edge of the great plateau is nearly triangular in shape, the two rivers and the edge of the plateau forming the sides. It also extends up the Gunnison, east of the western edge of the plateau, to longitude 107° 55′. The area of this part of the valley is three hundred square miles.

The western edge of the great plateau consists of a precipice of basalt, averaging 200 feet in height, below which there are timbered ridges

running down into the valley, and terminating in tongues of sloping mesa.

Between longitude 107° 55′, and the mouth of Roubideau's Creek, the Gunnison occupies the bottom of this valley, with a fertile bottom upward of two miles in width, in which the river is very sluggish and winding, with numerous sloughs and backwaters. Below the mouth of Roubideau's Creek the river does not occupy the lowest part of the valley; the latter lies between the river and the great plateau, about three miles, generally speaking, east of the former, and follows its general course. From this lowest part of the valley the land rises slowly toward the west, and, in a cañon, which originated in a monoclinal fracture, closely hugging the plateau on the west side of the valley, the Gunnison has its course. This cañon, known to the Indians as the Unaweep, is in stratified rocks, of the most brilliant colors. It has an average depth of about 800 feet, with walls absolutely vertical. The river-bottom is quite broad, and the river is sluggish and winding, now undermining one wall, now wandering across the broad and fertile bottom to the other. The soil in this bottom must be excellent for agricultural purposes.

The remainder of this great valley lies on the south side of the Gunnison River, extending up the Uncompahgre River for upward of forty miles, with an average width of eighteen to twenty miles. On the west it rises gradually into a plateau. On the east it is limited by the plateau in which the Grand Cañon of the Gunnison is cut, and by spurs from the Uncompahgre range, and on the south by this range. The stream-bottoms in this part of the valley are, as in the other, very fertile, and quite broad, with a heavy growth of cottonwoods. The rest of this portion of the valley consists of perfectly flat bench-land, rising in regular steps from the streams to an elevation of about 200 feet above them. Throughout the valley the bench-land is very poor, with a clay or gravelly soil, containing always some alkali, and in many places strongly impregnated with it. There is very little grass, indeed. Sage, grease-wood, and several species of cactus, form almost the sole vegetation. A great deal of the water sinks, so that, except in the spring, only the larger streams contain any water, and the water of the larger streams is more or less alkaline. Between the Grand and the Gunnison, Kahnah Creek and *b* creek (of the Gunnison) are almost the only streams containing water in October, and, south of the Gunnison, the Uncompahgre is the only stream in the valley which is not dry at that time of the year. Cedar Creek and Roubideau's Creek are dry. It is in this valley of the Uncompahgre and the Gunnison that the Utes usually have their winter quarters.

The Gunnison River heads under Italian peak, and its upper branches drain the southern slopes of the Elk Mountains and the western slopes of the Sawatch range. The branches which drain the Elk Mountains have a general direction of 30° east of south, as is the case with Slate River, East River, Ohio Creek, and the numerous parallel streams west of Ohio Creek. The main stream is in a narrow valley for several miles below its head, extending nearly down to the mouth of Pass Creek. Thence to Park Cone it is in a broad valley of gravelly soil, which is mainly a glacial deposit. At Park Cone, it enters a cañon, by which it cuts its way through the eastern range of the Elk Mountains. This cañon is cut in granite, is sixteen miles long and is, on an average, 1,200 feet deep. In this cañon, a large branch, Taylor River, enters the Gunnison from the north. Just below its foot, the next large tributary, Slate River, comes in. This stream and its tributary, East River, drain a

large part of the Elk Mountains. Most of their branches have the usual direction, and are in narrow valleys, with heavy, massive ridges between them. The lower part of Slate River, from Crested Butte to its mouth, is in a valley two to four miles in width, of the same character as that on the Gunnison above the cañon. This valley extends down the Gunnison to the mouth of Cochetopa Creek, with a width of about five miles. The river-bottom of the Gunnison in this part of its course is quite broad, and densely overgrown with bushes and cottonwoods.

Between Slate River and Ohio Creek, south of the termination of the mountains, are two rather remarkable pieces of table-land. They evidently were originally but one, but have been cut in two by erosion. Their surface slopes considerably toward the Gunnison.

At the junction of Ohio and Cochetopa Creeks with the Gunnison, the valley is very broad, extending far up Ohio Creek, with a broad bottom on each stream. In this valley, between the Gunnison and Cochetopa Creek, is located the embryo town of Gunnison. This town was started by a company, on the colony plan. Thus far it has not been a success, principally owing to its great distance from other settlements, and the limited means of communication. The situation is excellent, the soil very good, and, with the aid of irrigation, it will produce good crops. The range for stock, both for summer and winter, is not excelled in the Territory. This range now supports, throughout the year, the stock belonging to the Ute Indians of the Southern or Los Pinos agency, numbering about 900 head.

Below the mouth of Cochetopa Creek, the valley narrows to about a mile in width, which is all bottom-land, and which extends about four miles down the river. North of it the country rises, in a sloping plateau, to the Elk Mountains. This plateau is cut into long tongues by parallel streams—branches of the Gunnison. At the foot of this valley these long tongues of mesa run down to the river, forming a cañon 100 to 200 feet high, which extends, broken at intervals by bits of meadow-land, as far down as the mouth of *g* creek. On the south side, the country is very broken, but in general rises gradually toward the Uncompahgre Mountains.

West of the mouth of *g* creek the land rises rapidly on both sides of the river, into a high plateau. This plateau, on the south side of the river, is almost perfectly flat, with an average elevation of 9,000 feet. On the north side it slopes upward toward the northwest very gradually. At the river it has the same elevation as on the south side. It is in this plateau that the Gunnison cuts a part of its great cañon, a cañon fifty-six miles long and 3,000 feet deep in its deepest part. This plateau consists of gneiss, topped with 1,000 to 1,200 feet of stratified rocks, in beds nearly horizontal. The cañon is cut through the beds of stratified rocks, and deep into the gneiss, the depth of the cañon in the gneiss increasing with the fall of the river. This part of the cañon has rough, ragged, nearly vertical walls, with no beach to the river. On top of the gneiss there is a sloping bench, marking the line between gneiss and stratified rocks. Above this bench are the steeply-sloping walls of stratified rock, generally ending with 100 or 200 feet of perpendicular cliff just below the summit of the mesa. The tributaries of the Gunnison in this plateau cut but slightly into the gneiss, consequently these streams have a very rapid fall just before reaching the river. The top of this plateau is well watered, covered with excellent grass and groves of quaking aspen. It is a most excellent summer-range for stock, but the elevation is too great to allow of its use as a winter-range.

At stations 77 and 78, the character of the plateau changes, as far as

the north side of the river is concerned. The flat plateau ends in a very well-defined terrace, on an enormous scale, ten miles long and 1,800 to 2,000 feet high. In its place there is a lower sloping plateau, or long hog-back, with its edge at the Gunnison River, and line of greatest depression in the valley of the North Fork of the Gunnison. This is a true sloping plateau, its surface being perfectly flat and unbroken, with the exception of the cañons of Smith's Fork and Dry Cañon, which have a course nearly parallel to that of the Gunnison above station 80. These streams have many small gullies coming into them from the south, but none at all from the north. The line of greatest slope of this plateau has a direction slightly west of north. This plateau contains no water, and the vegetation consists of the piñon pine, cactus, sage, and scrub-oak, a marked difference in character from the plateau just east. This difference is owing in part to the greater slope of this plateau, thus carrying the water off more rapidly, and in part to the less elevation. The highest part, the edge, at the cañon of the Gunnison, is 8,600 to 9,000 feet, while the valley of the North Fork, the lowest part, is 5,400 feet. The character of the cañon on the north side, as far down as station 80, is similar to that above, both geologically and topographically. The stratified beds occupy 1,000 to 1,200 feet, with the same marked bench, and the precipitous cañon in gneiss below. On the south side, however, the top of the cañon is lower than it is above station 77, and the cañon is cut entirely in gneiss. The plateau on the south side is nearly horizontal, with a slight slope to the west.

At station 80 the river turns abruptly toward the north, and flows in the direction of the greatest slope. Between station 80 and the mouth of the North Fork it has most of its fall. On the east side of the river the character of the cañon is not materially changed until the mouth of Smith's Fork is reached. On the west side, however, the plateau ends abruptly opposite station 80, and a hog-back ridge of stratified rocks, dipping steeply to the west, forms the upper part of the west wall. This wall is much lower than that on the east, and is nowhere more than three miles thick. Beyond it is the broad, flat valley of the Uncompahgre, at as low or lower elevation than the Gunnison.

Between stations 80 and 81, the two parts of the cañon are very strongly marked, showing a cañon within a cañon. The cañon in gneiss is merely a narrow cleft in the rocks, with smooth, vertical sides, between which the river rushes down, its surface white with foam. At the mouth of Smith's Fork, the cañon in gneiss is but 300 feet deep, while the stratified rocks rise up to nearly a thousand feet. Just below this point it runs out of the gneiss, and the rest of its course is in stratified rocks, in which its character is entirely different. It no longer rushes madly along, but meanders about in the broad bottom from one wall to the other, leaving, now on this side, now on that, broad patches of beautiful bottom-land. This character of cañon, similar to the lower or Unaweep Cañon, continues as far as station 83, where it terminates abruptly.

The appended list of elevations in different parts of this cañon give an idea of its dimensions:

Height of the walls of the Grand Cañon of the Gunnison, at different points.

At the head, near the mouth of Mountain Creek:

		Feet.
At level of the river	a	7,200
Top of plateau on north side of the river	t	8,800
Height of cañon wall		1,600

At the mouth of *f* creek:

At level of river	*est*	7,100
Top of the gneiss	*a*	8,000
Height of cañon in gneiss		900
Top of plateau, east side *f* creek	*a*	9,000
Height of cañon wall		1,900
Top of plateau, west side *f* creek	*a*	8,900
Height of cañon wall		1,800

At station 77:

At level of river	*b*	6,800
Top of gneiss, north side of river	*a*	8,600
Height of cañon in gneiss		1,800
Top of plateau, north side of river, (station 77)	*a*	9,800
Height of cañon wall		3,000
Top of plateau, south side of river	*t*	9,400
Height of cañon wall		2,600

At station 80:

At level of river	*est*	6,200
Top of gneiss, northeast side of river	*est*	7,200
Height of cañon in gneiss		1,000
Top of plateau, northeast side of river, (station 80)	*a*	8,500
Height of cañon, northeast side		2,300
Top of plateau, southwest side of river	*t*	8,050
Height of cañon		1,850

At mouth of Smith's Fork:

At level of river	*est*	5,600
Top of plateau, east side of river, (station 81)	*a*	6,437
Height of cañon, east side		837
Top of plateau, west side	*t*	6,700
Height of cañon, west side		1,100

At mouth of North Fork:

At level of river	*a*	5,400
Top of plateau, east side, (station 82)	*a*	5,800
Height of cañon, east side		400

At foot of cañon:

At level of river	*a*	5,125
Top of plateau, (station 83)	*a*	5,750
Height of cañon		625

The North Fork of the Gunnison is its largest tributary. It drains nearly all of that part of the Elk Mountains west of Rock Creek, which consist principally of the isolated groups which have been described earlier in this report, and of most of the southern slope of the great plateau. Those of its branches which drain the mountains have no valleys worthy of mention within the mountains, and outside of them are in close cañon. The main stream heads against the divide between the Grand and Gunnison Rivers, in longitude 107° 30′, and drains a very broad valley. It enters a cañon in the rolling plateau country, in latitude 39°.4′, and in this cañon receives the branches known as Anthracite and Coal Creeks. This cañon continues as far down as the longitude of station 39, where the stream comes out into a valley, which is very

NOTE.—*b*, barometric measurement; *a*, aneroid measurement; *t*, trignometric measurement; *est.*, estimated.

similar to that of the Uncompahgre. This valley is at the foot of the sloping plateau in which is cut the Grand Cañon of the Gunnison. This stream enters a low cañon, just above its mouth, in which it enters the Gunnison.

DISTRIBUTION OF VEGETATION.

Vegetation, in its character and abundance, is modified by several causes. Elevation above sea-level is, perhaps, the most powerful in determining its character. The nature of the soil, amount of moisture, &c., are, of course, very powerful in influencing it. The general character of the vegetation as influenced by hight is as follows: The stream-bottoms, up to a height of at least 8,000 feet, produce abundantly cottonwoods and grass. The soil is deep and rich, and there is abundant moisture. The lower bench-land, up to a height of fully 8,000 feet, produces principally sage and greasewood, piñon pine, yucca, and cactus, with more or less bunch-grass. The soil is gravelly, or an alkaline clay, dry and arid. The upper benches and lower mountain slopes are covered with scrub-oak, piñon pine, wild service-berry and other bushes. This kind of vegetation is found at elevations from 7,000 to 10,000 feet above sea-level. The soil is quite dry, though not as dry as the last. From 10,000 to 11,000 or 11,500 feet, *i. e.*, to timber-line, on the mountains and plateaus, the characteristic vegetation is pine and spruce, with excellent grass. At these high altitudes the soil is very well watered.

SETTLEMENTS, TRAILS, ROADS, ETC.

Settlements west of the Sawatch range are very few and small. The only practicable way of reaching the country with wagons is by a long detour to the south, via the San Luis Valley and Cochetopa Pass, as none of the passes in the Sawatch range are practicable for wagons. Besides the embryo town of Gunnison, mentioned previously in this report, settlement is confined to a few mining camps in the Elk Mountains and the valley near the head of the Gunnison. There are small camps on Texas and Batty Creeks and in Union Gulch, near the head of the upper cañon of the Gunnison, working placer-deposits. At the head of Rock Creek, in the south end of Treasury Mountain, there is a camp of miners working quartz-leads. Washington Gulch has been worked, but is now abandoned. A small camp has been located on O-be-joyful Creek during the summer of 1874.

The whole of the area west of the one hundred and seventh meridian is within the reservation of the Ute Indians.

The only wagon-trails are from Gunnison up the Gunnison River and East River to the mining camps in Treasury Mountain and the trail made by Captain Gunnison in 1854, referred to above. This trail, though very rough and difficult, is occasionally used now.

Trails are abundant, leading in every direction, so that it would be an endless work to particularize them. The main trail connecting the Los Pinos and White River Indian agencies passes up Ohio Creek to its head, descends Anthracite Creek, ascends the North Fork, and follows Divide Creek, to its mouth, where it crosses the Grand. A heavy trail follows the Gunnison River from the mouth of Cochetopa Creek to its mouth on the north side. The great plateau is crossed by many trails, and nearly every stream has a trail along it.

CHAPTER II.

ELEVATIONS.

Elevations have been measured by cistern barometer, aneroids, and the vertical circle of the gradienter. Most of the mountain-summits in the western part of the Elk system and on the great plateau were measured trigonometrically by the vertical circle of the gradienter, based on the barometric elevations in the eastern part of the system.

REVISION OF THE HEIGHTS OF SUMMITS IN THE SAWATCH AND ELK SYSTEMS.

For a more accurate determination of the elevations of these mountains, I have employed a combination of the barometrical and trigonometric methods. By means of the vertical angles, between the peaks, their *relative* elevation has been determined with considerable accuracy. Then the heights of the several peaks, as measured by barometer, are reduced to a common point by use of these relative elevations. The mean of these results, giving suitable weights, gives a mean elevation for this common point, and, applying to it the difference in elevation, gives the heights of the other peaks. The accuracy of the results depends on the character of the leveling, the number of barometric elevations, and situation of the barometric base to which they are referred. In the Sawatch range, within the area over which I worked during the season of 1873, four peaks were measured by cistern-barometer. The barometric observations on these peaks were referred for a base to those taken near the summit of Mount Lincoln, at an elevation of 14,194 feet. The difference of elevation in no case exceeds 400 feet, and the greatest distance (to Mount Princeton) is forty-two miles, while the least (to La Plata Mountain) is but twenty-nine miles.

In the Elk Mountains five peaks have been measured by cistern-barometer, and referred to Mount Lincoln as a base. Of these the nearest to Mount Lincoln is Italian Peak, forty-four miles from it, while the one farthest off is Crested Butte, which is at a distance of fifty-five miles. The greatest difference in elevation is more than 2,000 feet.

The following is a summary of the work of reduction of the barometric elevations in these two mountain-systems, with the resulting elevations:

Sawatch range.

	Relative elevation.	Elevation of barometer.	Elevation of La Plata Mountain.	Mean elevation.
	Feet.	*Feet.*	*Feet*	*Feet.*
La Plata Mountain	0	14,302	14,302	14,311
Grizzly Peak	−355	13,962	14,317	13,956
Mount Harvard	+64	14,384	14,320	14,375
Mount Princeton	−115	14,199	14,314	14,196

In taking the mean of the elevations of La Plata Mountain, a double weight has been given to the result from the barometrical observation taken on this mountain, as it does not depend on vertical angles.

The small range of results on La Plata Mountain (only 18 feet) demonstrates the excellence of the Mount Lincoln base, and the importance of having the base as nearly as possible at the same elevation as the points measured.

From these points as bases the following heights have been measured, each result being the mean of a number of vertical angles taken with weights inversely proportional to the distances:

	Elevation.
	Feet.
Massive Mountain (highest summit)	14,298
Mount Elbert (northern and highest summit)	14,351
Mount Yale	14,187
Station 75	13,294

Elk Mountains.

	Relative elevation.	Elevation of barometer.	Elevation of Snowmass Mountain.	Mean elevation.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Snowmass Mountain	0	13,961	13,961	13,970
Castle Peak	+145	14,106	13,961	14,115
Crested Butte	—1,918	12,014	13,932	12,652
White Rock Mountain	—613	13,423	14,036	13,357
Italian Peak	—620	13,284	13,904	13,350

As before, double weight was given to the direct barometrical result on the common point, in this case Snowmass Mountain. The resulting elevations show much greater range than in the Sawatch system, as might be expected from the greater distance from the base, the great range in elevation, over 2,000 feet, and the fact that the great Sawatch range lies between these mountains and Mount Lincoln.

From these peaks as bases, the following elevations have been measured by vertical angles, each result being, as before, the mean of several independent measurements, giving suitable weights:

ELK MOUNTAINS.

	Latitude.	Longitude.	Elevation.
EASTERN RANGE.	° ′ ″	° ′ ″	Feet.
Capitol Mountain	39 9 0	107 4 40	13,997
Maroon Mountain	39 4 30	106 59 20	14,003
Mount Daly	39 11	107 4	13,193
Pyramid Peak	39 5	106 57	13,855
Sopris Peak	39 15 54	107 9 50	12,823
Teocalli Mountain	38 57 40	106 53 0	13,113
Station 63	38 54	106 30	12,464
Park Cone	38 48	106 36	12,021
Snowmass Mountain	39 7 12	107 3 44	13,970
Castle Peak	39 0 30	106 38 40	14,115
White Rock Mountain	38 58 30	106 55 10	13,357
Italian Peak	38 56 35	106 45 0	13,350
Bellevue Mountain	39 1	107 1	12,330
	39 12	107 4	12,050
	39 13	107 2	12,000
	39 2	107 2	12,240
	39 2	107 0	13,050
	39 0	106 52	13,400
	39 8	106 52	12,160
Between forks of Castle Creek	39 4	106 51	12,990
Do	39 5	106 51	12,720
	39 6	106 48	11,230

	Latitude.	Longitude.	Elevation.
	° ′ ″	° ′ ″	*Feet.*
Between Castle and Maroon Creeks	39 2	106 54	13,150
	39 3	106 46	12,330
	39 0	106 47	13,550
	38 58	106 47	12,750
	39 7	106 59	13,230
	39 6	106 58	12,900
	39 2	106 54	13,150
	39 1	106 58	13,200
	39 0	106 58	13,600
MIDDLE RANGE.			
Crested Butte	38 53	106 56	12,052
Gothic Mountain	38 57	107 0	12,570
Station 60	39 0	107 4	12,203
Treasury Mountain	39 1	107 6	13,200
Cinnamon Mountain	39 0	107 2	12,600
	39 8	107 10	12,750
	39 7	107 9	12,470
End of ridge north of last two points	39 12	107 11	12,050
	39 5	107 6	11,682
Top of Rock Creek Cañon, north side	39 4	107 7	11,430
WESTERN RANGE.			
Station 30	38 48	107 2	11,972
	38 50	106 59	12,399
	38 49	106 59	12,319
	38 49	106 58	12,259
	38 49	106 57 30	12,092
	38 48	106 57	11,547
Station 32	38 55	107 7	12,969
Station 33	39 2	107 15	12,481
	39 4	107 17	12,613
	39 2	107 17	12,578
Slate Mountain	39 0	107 6	12,891
Station 26	39 9	107 10	11,582
	38 53	107 3	12,220
	38 53	107 2	12,230
SCATTERED GROUPS.			
Mount Marcellina	38 56	107 14	11,324
	38 52	107 16	12,176
	38 51	107 15	12,003
	38 51	107 14	12,312
	38 51	107 13	12,250
	38 50	107 12 30	12,238
Station 31	38 43	107 12	12,920
	38 42	107 11	12,841
	38 43	107 13	12,861
	38 43	107 9	12,468
	38 45	107 12	12,746
	38 43	107 23	11,749
	38 44	107 22	11,715
Station 34	38 49	107 23	12,688
	38 45	107 24	10,838
Station 39	38 48	107 31	11,337
Station 38	38 46	107 33	10,634
	38 41	107 25	10,877
	38 47	107 28	11,713
	38 47	107 29	11,613

ON THE PLATEAU.

	Latitude.		Longitude.		Elevation.
	°	′ ″	°	′ ″	Feet.
GREAT PLATEAU.					
Station 42	39	0	107	45	10,632
Station 43	39	2	107	40	11,134
Station 44	39	3	107	41	11,128
	39	1	107	40	11,096
	39	4	107	56	10,900
Station 45	39	5	107	50	10,954
North end of plateau	39	6	108	13	9,800
South end of plateau	38	53	108	10	9,733
NORTH MAM PLATEAU.					
North Mam	39	23	107	51	10,973
South Mam	39	23	107	51	10,897
	39	22	107	55	10,621
	39	22	107	57	10,623
PLATEAU RANGE.					
Station 50	39	20	108	2	9,095
	39	19	108	1	7,545
	39	18	108	2	7,885
	39	17	108	4	7,930
	39	16	108	6	8,275
	39	16	108	7	8,625
	39	17	108	8	8,645

Approximate latitudes and longitudes of other important points.

	Latitude.		Longitude.	
	°	′	°	′
Tennessee Pass	39	22	106	19
Lake Creek Pass	38	59	106	33
Mouth of Lake Creek	39	5	106	10
Mouth of Cottonwood Creek	38	50	106	7
Mouth of Eagle River	39	30	107	3
Mouth of Roaring Fork	39	31	107	19
Mouth of Slate River	38	42	106	59
Mouth of White Earth River	38	29	107	13
Mouth of Cochetopa Creek	38	32	106	5[illegible]
Mouth of Lake Fork of the Gunnison River	38	27	107	29
Mouth of Cebolla Creek	38	28	107	31
Mouth of North Fork of the Gunnison River	38	47	107	50
Mouth of Uncompahgre River	38	45	108	5
Mouth of Gunnison River	39	4	108	33
Mouth of Plateau Creek	39	11	108	16

GRAND RIVER.

	Miles from mouth of Gunnison River.	Elevation.	Fall per mile.
		Feet.	Feet.
Grand Lake, Middle Park	224	8,153	....
Mouth Blue River, (head of cañon)	178	7,183	21.1
Foot of cañon in Park range	171	7,000	26.1
Mouth of Eagle River	114	6,125	15.4
Mouth of *a* creek	110	6,000	31.3
Mouth of Roaring Fork	95	5,734	17.7
Mouth of creek	89	5,645	14.8
Mouth of North Mam Creek	75	5,445	14.3
Mouth of Gunnison River	0	4,523	12.3

EAGLE RIVER.

	Miles from mouth.	Elevation.	Fall per mile.
		Feet.	*Feet.*
Tennessee Pass, (head)	62.0	10,418	....
Mouth of Homestake Creek	50.0	8,693	143.8
Mouth of Roche Moutonnée Creek	45.0	7,856	167.4
Mouth of Piney Creek	41.0	7,700	39.0
Mouth *f* creek (head of cañon)	29.0	7,065	52.9
Mouth *g* creek	13.0	6,601	29.0
Mouth *h* creek	6.5	6,389	32.6
Mouth	0	6,125	40.6

ROARING FORK.

	Miles from mouth.	Elevation.	Fall per mile.
		Feet	*Feet.*
Head	64	11,676	....
Mouth of Hunter's Creek	55	9,400	253
Mouth of Difficult Creek	48	8,241	166
Mouth of Castle Creek	43	7,942	60
Mouth of Frying-Pan Creek	25	6,626	73
Mouth of Rock Creek	12	6,000	48
Mouth	0	5,734	22

GUNNISON RIVER.

	Miles from mouth	Elevation.	Fall per mile.
		Feet.	*Feet.*
Head	200	11,176	....
Mouth of Pass Creek	185	9,869	153.8
Head of upper cañon	176	9,576	32.6
Mouth of Slate River	157	8,176	73.7
Mouth of Cochetopa Creek	141	7,725	28.2
At station 71	135	7,700	4.2
At foot open valley	130	7,638	12.4
Mouth of the White Earth	123	7,450	26.9
Mouth of *h* creek	116	7,350	14.3
Mouth of *g* creek	114	7,327	11.5
Mouth Lake Fork	112	7,213	57.0
Mouth of Cebolla Creek	97	6,800	27.5
Mouth North Fork	62	5,405	39.9
Mouth of *b* creek	50	5,226	14.9
Mouth Uncompahgre River	45	5,100	25.2
Mouth of Roubideau's Creek	40	4,925	35.0
Mouth	....	4,523	10.0

JUNCTION OF STREAMS.

	Elevation, Feet.
Mouth of Taylor River	8,300
Mouth of Deadman's Gulch	9,500
Mouth of Cement Creek	8,500
Mouth of East River	8,640
Mouth of Washington Gulch	9,000
Mouth of Cascade Creek	8,970
Mouth of Dyke Creek	10,840
Mouth of Ohio Creek	7,775
Forks of Ohio Creek	8,400
Mouth of branch *a* of Smith's Fork	6,745
Mouth of branch *b* of Smith's Fork	7,500
Mouth of branch *a* of North Fork	5,500
Mouth of branch *b* of Coal Creek	7,077
Mouth of branch *h* of Rock Creek	6,000
Mouth of branch *b* of Rock Creek	7,100
Mouth of branch *c* of Rock Creek	8,400
Mouth of branch *f* Plateau Creek	7,682
Mouth of branch *g* Plateau Creek	6,337
Mouth of branch *a* Plateau Creek	5,580

TOPOGRAPHICAL REPORT OF NORTHERN DIVISION, 1874.

By STORY B. LADD, M. E.

WASHINGTON, D. C., *June* 1, 1875.

SIR: I have the honor to submit to you the topographical report of the northern division of the United States Geological and Geographical Survey of the Territories, to which I was assigned as topographer, for the season of 1874.

The party, in charge of Mr. A. R. Marvine, geologist, left the rendezvous camp, near Denver, on the 20th of July. A camp was made for three days near Golden City, and a detailed survey made of the country between Ralston Creek and Mount Morrison. We crossed the Front or Colorado range by Berthoud's Pass, and traversed the Middle Park to our field of work north of the Middle Park.

The first station was made on the 1st of August, and the last one on the 20th of November. The wagon-road from the White River Indian agency to Rawlings Springs was taken, and Rawlings was reached on the 28th of November, and Denver, by railroad, on the 30th.

Mr. Wm. S. Holman, jr., took the supplies for the party, and a mercurial barometer to the White River agency, via Rawlings, and the wagon-road from that point. The barometric station which he established there is the base on which the majority of our altitudes depend.

The plan of the topographical work is exactly the same as used the year before, and as adopted by the other parties.

Very respectfully, yours,

STORY B. LADD.

Dr. F. V. HAYDEN,
United States Geologist, in charge of the United States Geological and Geographical Survey of the Territories.

REPORT.

The country assigned to the northern division, to be surveyed during the season of 1874, is north and east of the Middle Park, in Colorado. The northern limit was north latitude 40° 30′ and the southern the Eagle River from its source at the summit of the Mount Powell range to its junction with the Grand River, and then the Grand. On the east the work was to connect with that of the previous year on the western and northern sides of the Middle Park, and to the west the work was to be continued as far as the season would allow.

The most western point reached was nearly to longitude 108°, though the average limit is about 107° 45′. This arrangement gave us a narrow strip north of Middle Park, covering the southern end of the North Park, of an average width of about eleven miles, and extending from

the summit of the Front or Colorado range north of Long's Peak, west to the Park range, which is the eastern limit of the bulk of our work, and has a trend of north 25° west from Mount Powell. The disposition of the country made it desirable to commence at the eastern end of the North Park district, and to extend the work to the west toward our supply depot at the White River Indian agency, and when, early in November, we reached the country between the Mount Powell range and the headwaters of the Eagle, the storms and the clouds that hung constantly around the mountains made it impossible to continue the work, and we were obliged to leave that portion for another season.

The total area surveyed is about four thousand one hundred square miles of mountain country, interspersed with a few wide, open valleys. The methods of working are the same as adopted by the other parties. A line of primary triangulation stations bordering the country on the east and south and Dome Mountain near the center of the district, latitude 40° 00′ 57.″45, and longitude 107° 04′ 40.″46, (approximate,) were the points with which the secondary triangulation joining all the topographical stations were connected. Eighty-six principal stations were made, together with some minor compass stations along the lines of travel. The average distance of the stations apart was 6.84 miles.

A barometric station was established at the White River Indian agency, commencing on the 17th of August, and a meteorological record has been kept from that time to date. Different members of the party were observers while the party was in the field, and since then the observations have been made by Mrs. E. H. Danforth.

A portion of the party was encamped at the mouth of the Eagle River for twenty-six days, and a barometric record was kept there during the time, which gives the elevation of that point very accurately.

The station at the agency is the base used in the calculation of the majority of the heights; for the work done while the small side-party was at the mouth of the Eagle, that base was used as being much nearer, and the work done in the North Park previous to the establishment of the White River base depends upon the bases at Fairplay and Denver.

The southern end of the Medicine Bow Mountains, which border the North Park on the east, forms a high, precipitous, granite range between the valley of the North Grand and the Park. East of the North Grand rise the mountains of the great Front range, of the same general character as they are to the south, sharp, serrated summits, with amphitheaters on either side. The highest points of these ranges rise to a little over 13,000 feet, but the general elevation is 12,500 feet. To the north the Front range loses its rugged Alpine character and changes to a high, heavily-timbered plateau range, separated from the Medicine Bow by the Big Laramie River, and drained on the east by the Cache la Poudre. The range in the other direction bears south 40° east, and culminates in the highest mountain of the whole northern district, Long's Peak. The valley of the North Grand is narrow and close, excepting a portion of its lower course, where it widens into a broad beaver meadow.

Crossing the Medicine Bow range, we descend by long, broken spurs to the broad open prairie-like basin of the North Park, drained by the North Platte River. Across the Park rises the Park range, a broad, rounded mass, heavily timbered, about twelve miles in width, and with an elevation of from 10,000 to 10,500 feet. The range retains this character for fifty miles to the south, and then rises to the very rugged precipitous range of Mount Powell. To the north, for ten miles, it remains the same, and then changes to a more mountainous type, but not

as rough a one as to the south. The divide at the head of the Muddy Creek of Middle Park is very low, but 8,772 feet elevation; while at no point is the Park range lower than 9,000 feet, except where the cañon of the Grand cuts through it. So, if this cañon did not exist, the entire drainage of the Middle Park would flow through the Muddy Pass into the North Platte River.

The main spurs or ridges between Park View Mountain and the Park range, which, to the south from the divides between the Troublesome, the west fork of the Troublesome, and the Muddy, have a northwest and southeast trend parallel to the range.

Considering the country west of the Park range as a unit, the main topographical feature is the White River plateau, a lava capped mesa, irregular, and cut by deep cañons and valleys, which often nearly subdivide it.

This western district comprises about three thousand five hundred and twenty square miles, and the drainage is divided into three systems, the Yampah or Bear River, the White, and the Grand. The Yampah drains nearly the northern half of the district, the White the western central, about one-quarter, and the Grand the southern third.

The Yampah has a northeasterly and northerly course from its source on the eastern side of the mesa, which, situated in the center, is a point from which the drainage radiates, till it reaches the Park range within a mile of our north line, when it makes a sharp bend and holds a course due west till it joins the Green River.

The White River drains the heart of the plateau, and the main stream has its source in Trapper's Lake, which nestles in one of the deep-cutting valleys close under the cliffs. The South Fork of the White, heading near Shingled Mountain, cuts a deep precipitous cañon through the center of the plateau.

The Grand River, which issues from the Middle Park through the cañon in the Park range, flows through a broken series of gorges for ninety miles, opening out occasionally into a small valley of from one to five miles in length, but for the greater part of its course in rough, often impassable cañons. The Eagle flows through an open sage-brush valley for twelve miles and then through a narrow valley for five miles before it joins the Grand.

From the White River plateau, the surface of which is irregularly rolling, there rise a number of isolated mountains, Shingled Mountain, station XLI, and point 17-XLI, from 500 to 1,000 feet elevation above the general surface. These made excellent topographical stations. The eastern edges of the spurs, as well as of the main plateau, are the highest, sloping on the west to the edges of the mesa, and falling off on all sides with abrupt, high cliffs, to the long, sloping spurs below. To the east there are a number of ridges partially detached from the plateau, and the highest points of these are the mountains that show so prominently from the east, Dome Mountain and Mount Ornuo, which stand just south and north of the head of the Yampah, the highest mountains west of the Park range in this district.

The Dome Mountain ridge is entirely separated from the plateau, and the Mount Ornuo mass is connected by a narrow wall of rock, somewhat higher than the plateau at either end, in places but 3 feet in width, and a sheer precipice on both sides of from 700 to 800 feet. To the north lies the valley of the Williams Fork, a large tributary of the Yampah; to the south the headwaters of the Yampah itself. Standing near the center of this wall, which is 125 feet in length, with outstretched arms, and dropping a stone from each hand simultaneously, they fall for 100 feet before touching the sides of the cliffs. It was very much

cracked and shattered, and another winter will probably demolish this natural causeway.

The eastern edges of the plateau and the main spurs and ridges have a northwest and southeast trend, parallel to the Park range.

West of the Park range and parallel with it is a broken range, about ten miles distant from the axis of the main one. Starting as a spur from the Mount Powell mass it forms the high ridge of station LXXXI, reaching to 11,000 feet. The Grand has cut a cañon through the ridge, leaving a detached mountain, station LXXX, north of the Grand. North of station LXXX there is quite a low saddle; then it rises again to station LXXVII. To the north the Yampah has cut a small cañon through the range, but it there becomes lower, and soon falls off to the broad, low ridge of station XV. West of this range, and between it and the spurs from the plateau, lies Egeria Park, drained by the Yampah, the Chimney Fork, a tributary of the Yampah, and Bayard Creek, a branch of the Grand. It is an open, terraced basin, about twelve miles long from northwest to southeast, and from one to four miles wide. The divide between the Yampah and Grand River waters is only a very low gravel terrace, scarcely noticeable.

The valley of the Yampah, between stations XVII and XV, forms a small park about ten miles long and from one to three wide. Below the great bend of the Yampah, near station XV, for seven miles the valley is a wide, open bottom; it then closes into a cañon for nine miles, and then widens out into another rich and fertile bottom, extending almost continuously for eighteen miles down the river, and bordered on the north and south by low, rolling hills. It is in this valley that the new settlement of Haydenville is started, the beginning being made in November last.

Near the lower end of the bottom the wagon road from Rawlings' Springs on the Union Pacific Railroad to the White River Indian agency crosses the Yampah, and a small Indian trading-post, now kept by Mr. Morgan, is located there.

The valley of the Yampah is the finest and most promising of the whole district. This river is bordered by a growth of large cottonwoods, and the soil appears to be very fertile and productive. It has an elevation of from 6,200 to 6,800 feet. The only valley that rivals it in the least is that of the White River at Simpson's Park, where the agency is located; this, however, is on the Ute Indian reservation. Coal is found in a number of localities along the Yampah, between it and the White, as well as north of it, and although it has not been thoroughly explored and tested, yet it promises to be very abundant and of good quality, equal to any in the Territory. The Steamboat Springs are located right at the bend of the Yampah, on both sides of the river, and close to the bank on the north side. The water is lukewarm, of from 70° to 72° temperature, and is strongly saturated with sulphur.

At the head of a small stream, a tributary of the Eagle, draining the valley southwest of station LXXXII, there are a few quite small sulphur-springs, and on the banks of the Grand River, two miles below the mouth of the Eagle, there is another set of sulphur-springs on both sides of the river. A short distance below these springs there is a very large one that gushes forth close to the edge of the river, so that in the spring, at high stages of the river, it is entirely submerged. This spring has very little, if any, sulphur, though it probably has some salt, with possibly some other ingredients.

North of the White River plateau the country is mountainous and irregular, with no distinct, well-defined system.

The continuation of the spur, of which 6–XLI is the highest point,

forms the dividing range between the White River and the Williams Fork and Waddle Creek tributaries of the Yampah. It is a broad, rolling, heavily timbered range, with several prominent cone-summits, as Pagoda Peak and point 9–XXIX, and has three easy passes. An old trail crosses between Pagoda Peak and the plateau from the Williams Fork to the White; a good trail crosses between Pagoda Peak and point 9–XXIX from the main branch of the Williams Fork to the White, at an elevation of 8,300 feet, and the Government wagon-road crosses through Yellow Jacket Pass, west of station XXXI, at an elevation of 7,493 feet.

The plateau continues to the southwest, forming the divide between the White and the Grand Rivers, but it loses the distinctive mesa character to a great degree, and becomes more like a high, rolling range; the streams flowing south cut deep, profound cañons, while to the north sloping spurs and hog-back ridges divide the tributaries of the White.

ROADS AND TRAILS.

There are two roads that penetrate this country, the Government wagon-road from Rawlings' Springs, on the Union Pacific Railroad, to the White River Indian agency, and the one known as Berthoud's Salt Lake wagon-road.

The first, starting from Rawlings' Springs, crosses the old stage-road to Salt Lake City just west of Bridger's Pass, then following the valley of the Muddy, crosses the Little Snake at the settlements, and, crossing to Fortification Creek, follows that for most of its course, and fords the Yampah River just below the mouth of Elk Head Creek and half a mile east of Morgan's trading-post. It then follows a nearly straight course, crossing the Williams Fork and the Waddle, through Yellow Jacket Pass to the agency.

The second, which is a road surveyed by Capt. E. L. Berthoud, in 1861, from Golden City, Colo., to Provo City, in Utah, via Berthoud's Pass and the Hot Springs, in Middle Park, crosses the Park range at Gore's Pass at an elevation of 9,590 feet; then through the small group of meadows drained by Stampede Creek, across a low divide to Sarvis Creek, and down that valley to the Yampah. For the last few miles it leaves Sarvis Creek and follows down a small side-stream. Within a few years, since the discovery of mines on the Elk and Snake Rivers, a number of teams have been through by this route, and they have broken a road from Stampede Creek through to Egeria Park, and that is now the passable route, the former one down Sarvis Creek being but a trail.

Passing through Egeria Park and down the Yampah for seven miles, it follows a nearly straight northwesterly course across to Oak and Sage Creeks, then bearing to the west across a low divide east of station XXIV to Skull Creek, and once more meets the Yampah, which it follows down till it joins the Rawlins road. This is the route that is now used, but Captain Berthoud's surveyed road divides on Sage Creek, one branch passing up Sage Creek and across to the Williams Fork, and the other leaving the present road at Skull Creek, passing up Skull Creek to the Williams, where it joins the other branch, then across the hills to the range east of Waddle Creek, where it joins the present road to Simpson's Park and the agency. This portion of Berthoud's road from long disuse has become nothing more than a trail.

From Simpson's Park the road follows down the White to the junction of the Green, then up the Uintah River and the Duchesne Fork, and down the Timpanogos to Provo City, Utah.

The country is traversed by a great many well-defined trails in all directions. The principal ones across the Park View mountain-range, from the Middle to the North Park, are through the Willow-Creek Pass, east of Park View, at an elevation of 9,683 feet, and one across the low divide at the head of the Muddy Creek at an elevation of 8,772 feet. This is the pass crossed by Frémont, in 1844, on his return journey, and he speaks of it as one of the most beautiful passes he had ever seen. A fair trail crosses the Park range about five miles north of Rabbit Ears, a mountain near the Muddy Pass, capped with two sharp points of lava rock, to the valley of the Yampah, just above the great bend.

The most important trails in the western district besides those mentioned in connection with Berthoud's Salt Lake road are those leading to and from the Indian agency. A large Indian trail to the Cochetopa agency runs almost south from the White River agency, crossing the Grand at the mouth of Divide Creek, thirty-seven miles below the mouth of the Eagle, and then south up Divide Creek. A trail to the mouth of Eagle River follows up the White for five miles, then ascends the rolling plateau and crosses it in nearly a straight line to the junction of the Eagle and Grand, passing down the long spur west of Cañon Creek. The trail then follows up the Eagle River for twenty-one miles, and ascends the steep sides of the cañon of the Eagle to the valley southeast of station LXXI, the highest point between the Eagle and the Grand. It crosses this valley and the ridge dividing it from the Piney River, and passing along the steep mountain-sides on the east of the Piney and south of the Grand, it crosses the valley east of station LXXXI and the Park range through a pass 7.5 miles south of the cañon of the Grand and just north of point 5—XLI, and joins the Blue River trail in Middle Park.

The greater part of the whole country is abundantly watered, and the streams, with but few exceptions, are large and full. On the western edge the country becomes drier and more barren, and soon merges into the sterile, desolate region of Western Colorado. Longitude 108° is about the eastern limit of the barren waste. The country to the west is broken by low mountains, ridges, and terraces, but there are no commanding points, and away from the Yampah, White, and Grand Rivers water is very rarely found. Careful measurements were made of the Grand and Yampah Rivers so as to give the amount of water carried by them. This is an important question in case the country ever becomes settled enough to require irrigation, in order to utilize for cultivation the dry plains, especially on the Blue and Muddy in the Middle Park and along the Yampah, though there is no doubt that the supply is ample for any possible demand.

The Grand River was gauged at the hot springs, in Middle Park, on July 31. The river at that point was 84 feet in width, with a small side run 12 feet in width, and the greatest depth was 3 feet. The maximum velocity was 8 feet per second, and the amount of water 802 cubic feet per second. Early in November the river was gauged again at a point ninety miles below the springs, and just below the mouth of Eagle River, but the Grand is so much smaller at that time, it being at its minimum, that no direct comparison can be made between the two results.

The Blue, the Muddy, and the Eagle add their waters to the Grand between these two points, besides a great many smaller streams, yet the river measured only 871 cubic feet of water per second. The small amount is due to the lateness of the season, the river being then at its very lowest point. The width of the stream was 198 feet, the greatest depth 3.7 feet, and the maximum velocity 3.4 feet per second.

The Yampah was gauged in the middle of November, near the ford where the Rawlings wagon-road crosses, and this result also gives the minimum amount of water in it at any season of the year. The width was 156 feet, the deepest place 2.5 feet, the maximum velocity 2.4 feet per second, and the amount of water 364 cubic feet per second.

In the spring these rivers are very high and impassable until nearly July, and the Grand below the Blue is not fordable till August, and then only in a few places.

Plenty of water is naturally accompanied by an abundant growth of timber, and about one-half of the whole area is so covered, though a great deal of it is small, and of no value as lumber.

The Park range is covered with good large timber, similar to the Front range, mostly pines, but with aspens and small low trees along the lower edges. The Park View Mountain range and the Medicine Bow are the same, the hillsides well covered with flat areas, arms of the North Park, clear and open. These flat areas are covered with the lake deposits, and wherever these basins exist, as in Egeria Park, and the parks along Yampah, they are free from timber, with the exception of the cottonwoods bordering the streams.

The long sloping spurs from the White River plateau and the heads of the valleys draining it are well timbered, especially on slopes facing the north.

From the southeastern corner of the plateau, near station XLVII, and the long ridge that, starting at this point, runs southwesterly from this point around to the east and north to the mouth of the South Fork of the White, and beyond it to station LV, the country is well, and in places even heavily, timbered, covering about 700 square miles. The best timber, pine and spruce, grows on the heads of the White, Williams Fork, and Yampah Rivers, and on the top of the plateau between Shingled Mountain (station XLII) and station LIX. The spruce-trees growing on the top, at an elevation of from 10,500 to 11,000 feet above the sea, are large and fine, often reaching 3 feet in diameter.

A list is given of the elevations of the principal points and places. A few are calculated trigonometrically and those are marked with a *t*, and a few that are dependent upon an aneroid barometer are marked with an *a*; the rest are all obtained from a mercurial barometer.

List of elevations.

MOUNTAINS.

		Elevation, feet.
Station I, Front range		12,000
Station LX, (from '73,)	Medicine Bow range	12,513
Station II	Medicine Bow range	12,761
Station V	Medicine Bow range	*t* 13,060
Park View, (from '73,)		12,433
Station VII		11,906
Rabbit Ears	Park range	10,719
Point 3–LXXIV, south of Gore's Pass	Park range	*t* 10,620
Point 5–XLII	Park range	*t* 11,240
Station LXXXI		*t* 11,261
Station LXXI		11,336
Station LXXVII		*t* 10,430
Station XVII		8,774

WHITE RIVER PLATEAU.

	Elevation, feet.
Station LII, northeastern edge	*t* 11,210
Mount Ornuo	*t* 12,185
Dome Mountain	12,498
Mount Derby	*t* 12,253
Shingled Mountain, station XLII	12,072
Point 2–XLII	*t* 12,276
Station XLVI, southern edge	11,367
Station XLI	12,030
Point 17–XLI	*t* 11,957
Station LV	10,116
Pyramid Peak, station LI	11,611
Pagoda Peak	11,251
Point 9–XXIX	*t* 11,044
Station XXXI, east of Yellow Jacket Pass	9,431

PASSES AND DIVIDES.

Willow Creek Pass, } from the Middle to the North Park,	9,683
Muddy Creek Pass, } from the Middle to the North Park,	8,772
Gore's Pass, Park range	9,590
Divide south of station LXXXII, west of Piney Creek	*a* 8,422
Pass from Skull Creek to Williams Fork	*a* 7,797
Pass from main branch of Williams Fork to White River	8,300
Yellow Jacket Pass	*a* 7,493

ELEVATIONS OF PARKS, VALLEYS, ETC.

Valley of the North Grand	8,841
North Park, southeast corner	9,053
North Park, southern edge	8,596
Head of the Yampah or Bear River	10,600
Egeria Park, northern end	7,500
Yampah Valley, near station XV	6,781
Yampah Valley at Haydensville, mouth of Skull Creek	6,382
Yampah Valley at Morgan's trading-post	6,229
Valley of Sage Creek	6,948
Valley of Williams Fork, south of station XXVII	6,647
Valley of the Waddle, foot of Yellow Jacket Pass	6,654
Valley of the White, eleven miles above mouth of South Fork	7,592
Valley of the White at mouth of South Fork	6,972
White River Indian agency	6,491
South Fork of White, at lower end of cañon	7,551
Head of South Fork on plateau	10,900
Lake on plateau below station LVIII	10,337
Grand River, below cañon in Park Range	7,000
Grand River, mouth of Hughes' Creek	6,919
Grand River, near station LXIX	6,618
Grand River, in valley one mile above Shingle Creek	6,307
Grand River, mouth of Eagle River	6,116
Eagle River, at bend in cañon	6,790

MEANS OF COMMUNICATION BETWEEN DENVER AND THE SAN JUAN MINES.

By A. D. WILSON, *Topographer directing.*

The Denver and Rio Grande Railroad is now running daily trains to Colorado Springs, Pueblo, and Cañon City. Persons wishing to reach the new mining district may take the train to either of the three previously mentioned places, and at these points they will have to provide themselves with animals, except by way of Cañon City. From this place there was during last summer a regular line of stages running to Saguache and Del Norte, but from these latter places there is not at present any public conveyance. I mention the three points of starting, as they are all more or less traveled.

Colorado Springs is situated some seventy-six miles south of Denver on the Denver and Rio Grande Railroad. Leaving the railroad at this point, the traveler is obliged to procure his own conveyance, as there is not at present any public conveyance from there to Saguache or Del Norte. The road from here leads by way of Manitou up the Fontaine qui Bouille, crossing South Park at its southern end, passing by the Salt-Works; thence down Trout Creek to the Arkansas River, which it follows down some miles to the South Arkansas. At this point the road joins with the one from Cañon City, and then, following up Puncho Creek, leads through a pass of the same name, to San Luis Valley, thence skirting this valley along its western border to Saguache. This road is somewhat longer than the others, but a very good and pleasant one to travel, especially during the warmer portions of summer. The distance by this route from Colorado Springs to Saguache I estimated at one hundred and seventy miles.

The next route south is by way of Cañon City. This place is situated on the north bank of the Arkansas River, near where it emerges from the mountains, about one hundred and sixty miles from Denver by rail.

The road from Cañon City passes around the first cañon by keeping some distance to the north of the river, then, swinging south, crosses the river and again leaves it passing through the north end of Wet Mountain Valley, where it again turns to the north and strikes the river in Pleasant Valley; thence following up the river until it joins the Colorado Springs road, where it crosses the South Arkansas. It is about one hundred and ten miles by this road from Cañon City to Saguache. Pueblo is situated also on the Arkansas River, about thirty-five miles below Cañon City, and one hundred and eighteen miles by rail from Denver. The road leading out from this place crosses the plains toward the southwest and strikes the Huerfano River at Badito. At this point the road forks, one following up the river and crossing the Sangre de Cristo range through the Mosca Pass, thence crossing the San Luis Valley to Del Norte. The other branch of this road crosses the river, and keeps farther to the south, crossing the range through the Sangre de Cristo Pass, strikes the valley at Fort Garland, and crossing from there to Del Norte. Both branches have to contend with the

great sand-drifts which have accumulated on the eastern edge of the San Luis Valley; the one by way of Mosca Pass being probably the shortest by some miles, but at the same time having more sand to contend with. With the exception of the sand, this is a very good road. I estimated the distance from Pueblo to Del Norte by Mosca Pass to be one hundred and twenty miles. I merely mention briefly these different roads to Saguache and Del Norte to give the traveler some idea how to reach these points, as they are the last places of any note on the way. Saguache is located on a small stream of the same name, where it leaves the mountains and enters the San Luis Valley. The enterprising citizens of this place have already gone to considerable expense in building a wagon-road which is to connect this place with the San Juan mines. But I fear it will take more labor and money to make it a good road than they at present can afford to expend on it. This road is only approximately located on the accompanying map, owing to its unfinished condition when we passed through that portion of the country. The construction party was, when we passed them, August 12, nearly up to the junction of Godwin Creek and Lake Fork. They had brought their supplies over the road in wagons, but there were many places where much labor would be required to make it practicable for heavily-loaded wagons. From this point on they will meet their greatest obstacles. As I understood them, they intended following approximately the course of the trail—that is, up Lake Fork. By this route they can get a very good grade, but only with considerable expense, until nearing the pass, where the mountains rise quite abruptly, and it will be very difficult to construct a good road over this pass, as it is quite steep on either side. This pass is 12,540 feet above sea-level.

The trail over this pass strikes Animas River near its head, where many silver-bearing lodes have already been located. From this point it follows down the river to Howardville, a distance of about nine miles, a portion of the way being over very steep and loose *débris* slopes, over which it will be difficult to construct a road. The distance by this road from Saguache to Howardville will be about one hundred and thirty miles. There is also a trail from Saguache, which is a much shorter route for pack or riding animals than the road, but a small connecting-link is wanting, which any one can easily supply by taking the accompanying map on which the trail is indicated.

From Los Pinos agency the trail follows up one of the branches of Cochetopa Creek, thence crossing over to the White Earth, which it follows up until nearing the divide between it and the Rio Grande. Here it turns to the south and descends to Antelope Park. But the traveler wishing to go to San Juan must keep on in a westerly direction, and he will soon strike a trail which leads him down to San Cristoval Lake, where he will strike the Lake Fork trail, formerly described. The distance by this trail from Saguache to Howardville is about one hundred and ten miles.

Del Norte is located on the southern bank of the Rio Grande, near the foot-hills on the west side of San Luis valley, about thirty miles south of Saguache. This being the nearest place to the mines, it is from here that the miners procure their supplies at present. The wagon-road from Del Norte follows up the river along its southern bank, meeting with no obstacles of note until reaching Wagon-Wheel Gap. At this point, owing to a loose slide, the owners of the road were compelled to change it by building a bridge over the river. This bridge was nearly completed when we passed there. The road only crosses to recross again very soon, and continues on the southern bank until nearing Bristol Head. Here it crosses to the

northern bank; then, soon leaving the river, and skirting the foot of the mountain, crosses a low spur, and descends to Antelope Park. This point is about fifty-five miles from Del Norte. So far the road is very good, having no heavy grades, and, passing as it does over the gravelly bottoms, it is naturally solid and quite smooth for a mountain-road. At this point the road again leaves the river, following up Crooked Creek for about eight miles; reaches a high pleateau, which it crosses, bearing again toward the river; descends a high and quite steep bluff; crosses and recrosses the river, when it again leaves the river for a short distance, coming upon its bottoms once more at the Half-way House. So far the road is passable for lightly loaded wagons; but from here on it is of no use in its present condition, as it is about all they can do to get an empty wagon over it. From the Half-way House the road follows up the river for some distance, when it turns to the right, and ascends quite a steep slope, winding its way along to the pass. It is at this point that the greatest difficulty is met with, owing, first, to the sudden descent of the slope from the pass to Baker's Park, the whole distance being some four miles, with a descent of 2,900 feet, and in the first two miles a descent of about 2,300 feet; and, secondly, owing to the very rocky and bluffy charater of the slopes, it will be very difficult to give the road swing enough to get anything like a good grade. Still this appears to be the most practicable route at present, as there is a good road for so much of the way.

The trail from Antelope Park does not follow the same course as the road; it more nearly follows the river, and crosses a pass about one mile farther south, near the head of Cunningham Creek. This pass is a few feet lower than the one through which the road goes. Height of trail-pass above the sea-level, 12,090 feet.

The distance by the road from Del Norte to Howardville is about ninety-five miles. There is a trail leading from Howardville down the Animas; also another leading out to the northwest to the headwaters of the San Miguel and Dolores. Both of these trails have been described by Mr. Rhoda.

The accompanying map gives the drainage in detail of the country immediately surrounding the San Juan mines, with all the important mountain-peaks, roads, trails, and other features of the country that could be represented within the limited time at my disposal. The lower portion of the Rio Grande was located preliminarily in order to show the route of the wagon-road from Del Norte.

The heights of many of the important peaks and valleys are given on the map; and there will be a list giving the heights of all the higher peaks and other important points, with an explanation of the method used in their determination by Mr. Rhoda, who has worked them up with great care.

The small contour map of Baker's Park and vicinity will give an idea of the character of the country which we were engaged in working up the past season. It will also give some idea of the care with which this region has been surveyed. Owing to the want of time, I was not able to get more of the country drawn finally for this report.

Mr. Rhoda has written quite a detailed description of the country. Therefore I will refer the reader to his chapter for any information that may be sought in regard to the appearance or character of this region. Dr. Endlich has also written a geological and mineralogical report of the region surveyed.

Fall of the Rio Grande from Cunningham Pass to Del Norte, commencing at pass.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To the mouth of Pole Creek	4½	1,300	288.9
Thence to Lost Trail Creek	8½	1,200	141.1
Thence to Antelope Park	15	600	40
Thence to Del Norte	60	1,100	18.3

Fall of the Animas from divide between it and east branch of Uncompahgre to the lower end of Animas Park.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To upper end of Baker's Park	8	2,600	325
Thence to lower end of park	8	500	62.5
Thence to mouth of Cascade Creek	17	1,700	100
Thence to head of Animas Park	10	800	80
Thence to lower end of Animas Park	14	300	21.4

Fall of Los Pinos from Weminuche Pass, commencing at summit of pass.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To point where trail leaves stream	6	782	130.3
Thence to west branch	9	1,200	133.3
Thence to Vallecito Creek	12	1,000	83.3
Thence to Big Bend	6	400	66.6

Fall of Vallecito Creek from divide between it and Rio Grande, commencing at divide.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To junction of south branch	5	2,400	480
Thence to Los Pinos	21	2,800	133.3

Fall of Rio San Miguel, commencing at Bear Creek Pass.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To valley below pass	2	2,400	1,200
Thence down stream	4	600	150
Do	2	800	400
Thence to junction of east branch	6	1,100	183.3

Fall of Uncompahgre from divide between it and Mineral Creek, commencing at divide.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To small valley	4	1,400	350
To lower end	2	200	100
To lower end of cañon	4	1,500	375
To junction of west branch	14	1,000	71.4

Fall of Lake Fork, commencing at divide west of Handie's Peak.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To valley	2½	2,200	880
Thence to junction of south branch	5½	1,200	218
Thence to mouth of Godwin Creek	15	1,200	80
Thence to point where road strikes creek	21	800	38.9

Fall of Godwin Creek, commencing at divide between it and Uncompahgre.

	Distance.	Fall.	Fall per mile.
	Miles.	*Feet.*	*Feet.*
To junction with north branch	7½	2,800	374
Thence to Lake Fork	10	1,000	100

COMPARISONS OF ANEROIDS WITH THE MERCURIAL BAROMETER.

The following table gives the comparisons of the aneroids with the mercurial barometer at different altitudes, ranging from 5,000 to over 14,000 feet above sea-level. These comparisons were made very carefully, and as often as practicable, hoping thereby to have a good check on any heights which were dependent on the aneroids; and at the same time wishing to see if there was any regularity in the movements of the aneroids. But there does not appear to be any regularity in the changes which they undergo. Generally, in going up or down any considerable height in a short time, the aneroids would not change fast enough; therefore would make the difference between points too small, while at the same time they always indicated too great an absolute height, always reading less than the barometer.

In the tables given below, the readings of the barometer are reduced to 32° Fahrenheit. The aneroids are supposed to be compensated for temperature.

The corrections to be applied to the aneroids are placed in separate columns, with the sign prefixed, which in this case is always plus, as the aneroids constantly read lower than the barometer.

The instruments used were Green's cistern-barometer, and the small watch-aneroids by the same maker.

Location.	Time.	Date.	Barometric readings reduced to 32° Fahrenheit.	Readings of aneroid No. 12.	Readings of aneroid No. 15.	Readings of aneroid No. 16.	Corrections to aneroid No. 12.	Corrections to aneroid No. 15.	Corrections to aneroid No. 16.
Camp 12	3 p. m.	July 29, 1874	21.854	21.13	21.10	......	+ .724	+ .754	+ .090
Camp 13	7 a. m.	July 30, 1874	21.717	......	20.86	20.10	......	.857	1.617
Station 2	2 p. m.	July 30, 1874	18.633	18.10	17.80	17.00	.533	.833	1.633
Station 3	1 p. m.	July 31, 1874	19.177	18.60	......	......	.577	......	......
Station 5	12.45 p. m.	Aug. 1, 1874	19.023	18.40	......	......	.623	......	......
Camp	6 p. m.	Aug. 1, 1874	20.608	19.82	......	......	.788	......	......
Station 6	2 p. m.	Aug. 3, 1874	21.275	20.48	......	......	.795	......	......
Station 7	10 a. m.	Aug. 4, 1874	21.752	21.00	......	......	.752	......	......
Station 8	2 p. m.	Aug. 6, 1874	18.924	18.34	......	......	.584	......	......
Camp 20	7 a. m.	Aug. 7, 1874	22.134	21.27	......	......	.864	......	......
Camp 22	11.50 a. m.	Aug. 7, 1874	21.610	20.71	......	20.15	.900	......	1.460

Location.	Time.	Date.	Barometric readings reduced to 32° Fahrenheit.	Readings of aneroid No. 12.	Readings of aneroid No. 15.	Readings of aneroid No. 16.	Corrections of aneroid No. 12.	Corrections of aneroid No. 15.	Corrections to aneroid No. 16.
Camp 21	7 p. m	Aug. 7, 1874	19.667	19.00	18.70	17.90	.667	.967	1.867
Station 9	8 a. m	Aug. 8, 1874	18.039	17.47	......	16.40	.519	....	1.639
Station 10	1 p. m	Aug. 10, 1874	18.657	17.97	......	.. ..	.687	.....	1.800
	9.30 a. m	Aug. 11, 1874	21.200	....	19.95	19.40	....	1.230	......
Camp 24	7 a. m	Aug. 11, 1874	22.133	21.18	21.09	20.37	.953	1.043	1.863
Station 11	12 m	Aug. 12, 1874	20.563	19.70	......	......	.863	....	....
Camp 25	7 p. m	Aug. 12, 1874	21.093	20.73	20.57	19.90	.963	1.123	1.793
Camp 26	7 a. m	Aug. 14, 1874	21.579	20.60	20.52	19.82	.979	1.059	1.758
Station 13	2 p. m	Aug. 14, 1874	19.017	18.30	....	....	.717	....	....
Camp 27	7 a. m	Aug. 15, 1874	20.876	20.00	19.80	19.65	.876	1.076	1.826
Station 14	1 p. m	Aug. 15, 1874	18.213	17.55	....	....	.663	....	....
Camp 28	7 a. m	Aug. 16, 1874	20.465	19.69	19.33	18.68	.775	1.135	1.785
Pass	9 a. m	Aug. 16, 1874	19.210	18.40	18.10	17.40	.810	1.110	1.810
Animas	2 p. m	Aug. 16, 1874	20,262	....	....	18.30	....	....	1.962
Station 16	11.30 a. m	Aug. 17, 1874	18.532	17.83	......	....	.702	....	....
Camp 29	4.30 p. m	Aug. 17, 1874	21.307	....	....	19.40	....	....	1.907
Pass	11.30 a. m	Aug. 18, 1874	19.461	....	18.37	17.76	....	1.091	1.701
Camp 30	6 a. m	Aug. 19, 1874	19.924	19.09	....	18.20	....	....	1.734
Camp 31	8 p. m	Aug. 19, 1874	20.186	....	....	18.45	....	....	1.736
Camp 31	7 a. m	Aug. 20, 1874	20.203	19.30	19.06	18.46	.903	1.143	1.743
Camp 33	7 a. m	Aug. 22, 1874	20.502	19.60	19.42	18.72	.902	1.082	1.782
Station 21	1 p. m	Aug. 22, 1874	18.343	....	17.14	16.52	....	1.203	1.823
Camp 33	7 a. m	Aug. 23, 1874	20.514	19.38	19.32	....	1.134	1.194	....
Camp 34	7 a. m	Aug. 24, 1874	19.919	19.01	18.80	18.12	.909	1.119	1.799
Camp 36	7 a. m	Aug. 28, 1874	19.906	19.04	18.73	18.04	.866	1.176	1.866
Camp 38	7 p. m	Aug. 29, 1874	21.594	20.54	....	19.81	....	....	1.784
Silverton	6 p. m	Aug. 31, 1874	21.518	20.50	......	....	1.018	....	....
Camp 39	6 p. m	Sept. 2, 1874	21.307	20.31	20.10	19.56	.997	1.207	1.747
Station 29	2 p. m	Sept. 4, 1874	18.688	17.90	......	....	.788	....	....
Camp 41	6 a. m	Sept. 5, 1874	20.816	19.88	19.61	19,11	.936	1.206	1.706
Pass	9.30 a. m	Sept. 5, 1874	20.202	19.30	19.07	18.47	.903	1.133	1.733
Camp 39	1 p. m	Sept. 5, 1874	21.345	20.29	20.10	19.54	1.055	1.245	1.805
Camp 42	7 a. m	Sept. 6, 1874	21.146	20.15	19.94	19.43	.996	1.206	1.716
Station 30	2 p. m	Sept. 6, 1874	18.195	17.45	....	....	.745	....	....
Camp 43	7 a. m	Sept. 8, 1874	20.424	19.48	19.20	18.56	.944	1.224	1.864
San Miguel Lake	12 m	Sept. 8, 1874	21.132	....	....	19.17	....	....	1.962
Camp 44	4 p. m	Sept. 8, 1874	21.841	....	20.63	19.94	......	1.211	1.901
Camp 45	6 p. m	Sept. 9, 1874	20.663	19.70	19.44	18.85	.963	1.223	1.813
Station 33	2 p. m	Sept. 10, 1874	17.865	17.20	......	....	.665	....	......
Camp 46	6 a. m	Sept. 12, 1874	21.913	......	....	20.08	....	......	1.933
Station 35	2 p. m	Sept. 13, 1874	17.815	17.10	....	16.04	.715	......	1.775
Camp 47	6 a. m	Sept. 14, 1874	20.397	.....	19.24	18.64	......	1.157	1.757
Station 37	1 p. m	Sept. 15, 1874	19.008	18.13	17.79	17.20	.878	1.218	1.808
Camp 48	7 a. m	Sept. 16, 1874	20.686	19.64	19.50	18.89	1.046	1.186	1.796
Pass	2 p. m	Sept. 19, 1874	20.576	19.56	19.37	18.71	1.016	1.206	1.866
Station 38	2 p. m	Sept. 20, 1874	18.663	17.85	......	......	.813	......	......
Camp 52	6.30 a. m	Sept. 21, 1874	20.977	19.90	19.80	19.10	1.077	1.177	1.877
Camp 53	8.30 a. m	Sept. 22, 1874	21.879	20.73	20.63	19.98	1.149	1.249	1.899
Camp 54	7 a. m	Sept. 23, 1874	23.557	22.45	22.49	21.72	1.107	1.067	1.837
Station 40	12 m	Sept. 23, 1874	22.116	21.09	......	.....	1.026	......	......
Camp 55	5 p. m	Sept. 23, 1874	23.678	......	......	21.76	......	......	1.918
Camp 55	7 a. m	Sept. 24, 1874	23.725	22.70	22.72	21.95	1.025	1.005	1.775
Camp 56	7 a. m	Sept. 26, 1874	23.452	......	22.39	21.66	......	1.002	1.792
Station 44	1 p. m	Sept. 26, 1874	22.503	21.40	.....	....	1.103	....	....
Camp 57	6.30 p. m	Sept. 27, 1874	23.927	......	22.93	22.18	......	.997	1.747
Camp 57	6.30 a. m	Sept. 28, 1874	24.006	23.00	23.02	22.35	1.006	.986	1.656
Station 47	4 p. m	Sept. 28, 1874	21.856	20.87	.....	.....	......	......	.....
Camp 58	6.30 a. m	Sept. 29, 1874	23.123	22.13	22.16	21.49	.993	.963	1.633
Camp 59	6 a. m	Sept. 30, 1874	22.577	21.60	21.59	20.80	.977	.987	1.777
Station 50	12.30 p. m	Oct. 1, 1874	22.873	21.80	.....	......	1.073	.....	.....
Camp 60	7 a. m	Oct. 2, 1874	21.453	20.43	20.31	19.76	1.023	1.143	1.693
Station 51	10.30 a. m	Oct. 6, 1874	19.065	18.22	......	....	.845	....	....
Station 53	10 a. m	Oct. 8, 1874	20.874	19.90	......	....	.974	....	....
Station 54	2.30 p. m	Oct. 9, 1874	19.088	18.25	......	....	.838	....	....
Station 58	12 m	Oct. 12, 1874	22.271	21.20	......	....	1.071	....	....
Station 62	11 a. m	Oct. 15, 1874	22.021	20.95	......	....	1.071	....	....
Station 63	12.20 p. m	Oct. 16, 1874	21.872	20.83	......	....	1.042	....	....
Camp 73	7 a. m	Oct. 17, 1874	24.854	23.31	23.80	....	1.044	1.054	....
By Station 64	9 a. m	Oct. 17, 1874	23.646	22.60	....	......	1.046	....	....
Camp 74	6 p. m	Oct. 18, 1874	24.633	23.62	....	22.92	1.013	....	1.713

Location.	Time.	Date.	Barometric readings reduced to 32° Fahrenheit.	Reading of aneroid, west.	Reading of aneroid, east.	Correction to aneroid, west.	Correction to aneroid, east.
Camp 1	6 p. m.	July 3, 1873	24.371	24.01	23.10	.361	1.271
Do	6 a. m.	July 4, 1873	24.496	24.17	23.23	.326	1.266
Camp 2	6 p. m.	July 4, 1873	22.251	21.94	21.11	.311	1.141
Do	6 a. m.	July 5, 1873	22.254	21.96	21.10	.294	1.154
Camp 3	7 p. m.	July 5, 1873	22.200	21.90	21.04	.300	1.160
Do	6 a. m.	July 6, 1873	22.237	21.95	21.10	.287	1.137
Camp 4	6 p. m.	July 7, 1873	21.181	20.83	20.06	.351	1.121
Camp 5	6 a. m.	July 8, 1873	21.035	20.70	19.90	.335	1.135
Camp 6	7 p. m.	July 8, 1873	21.850	21.43	....	.420	....
Camp 8	6 a. m.	July 10, 1873	24.347	18.41	22.02	4.937	1.327
Station 1	1 p. m.	July 10, 1873	21.260	16.25	20.07	5.010	1.190
Camp	6 p. m.	July 10, 1873	22.733	17.70	21.40	5.033	1.333
Camp	7 p. m.	July 11, 1873	22.625	17.55	21.25	5.075	1.375
Camp	5 a. m.	July 14, 1873	23.515	18.14	22.13	5.375	1.385
Camp	7 p. m.	July 14, 1873	23.288	17.90	21.89	5.388	1.398
Camp	6 a. m.	July 16, 1873	23.447	18.10	22.08	5.347	1.367
Camp	5 a. m.	July 17, 1873	24.611	19.21	23.14	5.401	1.471
Camp	7 p. m.	July 17, 1873	25.036	19.60	23.62	5.436	1.416
Camp	5 a. m.	July 18, 1873	25.062	19.61	23.68	5.452	1.3 2
Camp	7 p. m.	July 19, 1873	22.813	17.30	21.55	5.513	1.263
Camp	6 a. m.	July 21, 1873	22.527	17.10	21.29	5.487	1.297
Camp	6 p. m.	July 22, 1873	22.673	17.15	....	5.523	....
Camp	7 p. m.	Aug. 3, 1873	22.007	....	20.50	....	1.507
Camp	6 a. m.	Aug. 5, 1873	22.539	....	21.02	....	1.519
Camp	6 p. m.	Aug. 8, 1873	22.038	....	20.50	....	1.538
Camp	7 p. m.	Aug. 11, 1873	20.542	....	19.10	....	1.442
Station 59	12 m.	Sept. 5, 1873	19.766	....	18.39	....	1.376
Station 67	9 a. m.	Sept. 11, 1873	21.375	....	20.00	....	1.375
Station 73	9 a. m.	Sept. 14, 1873	22.689	....	21.10	....	1.589
Station 76	11 a. m.	Sept. 17, 1873	21.232	....	19.99	....	1.242
Station 87	6 p. m.	Sept. 25, 1873	22.096	....	20.57	....	1.526
Camp	7 a. m.	Sept. 26, 1873	22.431	....	20.91	....	1.521
Station 89	5 p. m.	Sept. 28, 1873	20.509	....	19.18	....	1.329
Station 90	2 p. m.	Sept. 29, 1873	21.094	....	19.70	....	1.394
Station 94	10 a. m.	Oct. 2, 1873	21.117	....	19.75	....	1.367
Station 95	3 p. m.	Oct. 2, 1873	22.289	....	20.76	....	1.529

Location.	Barometric readings reduced to 32° Fahrenheit.	Readings of aneroid, No. 4.	Readings of aneroid, 0.	Readings of aneroid, No. 3.	Correction to aneroid, No. 4.	Correction to aneroid, 0.	Correction to aneroid, No. 3.
Camp	21.103	20.94	20.59	20.95	.163	.513	.153
Station	18.605	18.43	18.20	18.48	.175	.405	.125
Camp	21.072	20.90	20.50	20.90	.172	.572	.172
Do	20.812	20.73	20.30	20.66	.082	.512	.152
Station	18.322	18.18	17.80	....	.142	.522	....
Camp	20. 47	20.525	20.11	20.55	.222	.637	.197
Do	20.003	19.775	20.36	20.79	.228	.643	.213
Station	18.190	18.00	17.50	....	.190	.690	....
Camp	21.034	20.70	20,23	....	.334	.804	....
Do	20.145	19.99	19.45	19.88	.155	.695	.265
Station	18.570	18.34	17.87	....	.230	.700	....
Camp	20.134	19.98	19.44	19.86	.154	.694	.274
Do	19.613	....	18.96	Gardner's	......	.653	Gardner an.
Station	17.934	17.79	17.18	17.15	.144	.754	.784
Camp	20.986	20.65	20.25	....	.336	.736	....
Do	20.029	19.775	19.39	18.94	.244	.639	1.089
Station	17.946	17.74	17.28	17.04	.206	.666	.906
Camp	20.064	19.55	19.18	18.81	.514	.884	1.254
Do	19.798	19.45	19.06	18.67	.348	.738	1.128
Station	18.127	17.89	17.35	17.14	.237	.777	.987
Camp	20.724	20.20	19.81	19.36	.524	.914	1.364
Station	18.658	18.30	17.79	17.53	.358	.868	1.128
Camp	20.572	20.10	......	No. 3.	.472	......	No. 3.
Do	20.283	19.89	19.49	19.95	.393	.793	.333
Station	18.114	17.775	17.29	18.02	.339	.824	.094
Camp	20.176	19.775	19.34	....	.401	.836	....
Station	19.424	18.99	18.64	....	.434	.784	....
Camp	21.749	21.32	....	....	.429	......	....
Station	19.469	19.08	....	....	.389	......	....

REPORT ON THE TOPOGRAPHY OF THE SAN JUAN COUNTRY.

By Franklin Rhoda, Assistant Topographer.

In the following report I have adopted the very common system of describing the country in the order of our travels through it. The system is a very faulty one, but seemed to be the best possible under the circumstances. In describing a river or a simple range of mountains, the order of sequence is laid down in nature; all you have to do is to commence at one end of the line and follow it. The mountains in the so-called San Juan country, however, are very complicated, and present no definite lines that may be followed in a description without leaving much untold. They appear, not in a single range, nor in a succession of ranges, but as a great mass. It was thought best to intersperse here and there in the description of topography such personal adventures of members of the party as might throw light on any features of the country or its climate.

We started from Colorado Springs on the 14th of July, 1874, taking the road leading up the Fontaine qui Bouille, and over Ute Pass into South Park. It would have been much shorter to have gone to Pueblo by rail, and thence on horse or mule-back around the southern end of the Greenhorn Mountains, through Huerfano Park and Mosca Pass, and across San Luis Valley to Del Norte. But at this time of the year we knew that along the low plains the heat would be intense and the grass and water scarce. As it was we had a delightfully cool trip all the way, with plenty of grass for our animals. Our road lay across South Park, thence down the Arkansas River and across the range at Puncho Pass into the San Luis Valley. We reached Saguache on the 24th of July, and made inquiries of different persons as to the nature of the country for which we were bound; but although they were all deeply interested in the prospects of the new mines, nobody could give us any definite information. We could not even find out whether the country was made up of rugged mountains or only high plateaus. Two days after leaving this place we reached the Los Pinos agency, where the Southern Utes receive such supplies as are apportioned to them by the Government. This point was in the extreme southwest corner of the district surveyed in 1873, and was the point of beginning the past summer.

Our first station was made on a peak which had been occupied in 1873 as station 34. It is a low point, a few miles northwest of the agency, and is less than 12,000 feet in elevation. Having a most beautiful day, and plenty of time at our disposal, we found it very pleasant to study the country that appeared in the southwest, in which our summer's work was to be. We could see none of the very rugged masses of mountains which beset our path and taxed our energies in the months following. What did appear to us was as follows: A little to the west of south, and not more than fifteen miles distant, rose up the high group in which station 33 of 1873 was situated, and containing several peaks ranging in height from 13,500 to near 14,000 feet. Farther around to the west, but much more distant, appeared a high pyramidal-shaped peak,

which is situated south of the Rio Grande, and is marked on the map as Rio Grande Pyramid. A little farther to the right, and still more distant, was a double-topped peak, afterward occupied as station 23, and named Mount Oso. Still farther around, another distant, high peak appeared to be the culmination of a high mountain mass; this is Mount Æolus on the map. Nearly in the same direction, but much nearer, there appeared a high plateau, extending over many degrees of the horizon. Being more than twenty miles distant from us, and lying wholly above timber-line, it was a very interesting feature in the landscape. At our distance it seemed to be covered with grass; but this we afterward found was not the case. Our subsequent experience showed us that in this part of the country these high super-timber-line plateaus are very common. Immediately beyond this area was a high mass of red-colored mountains, afterward the scene of some interesting electrical experiences. A few miles northwest of this group Uncompahgre Mountain appeared, presenting on its north side the peculiar precipice which distinguishes it from all the surrounding peaks. North of this a series of ridges and plateaus extends from the high mountains to the Gunnison River.

Having made profile sketches of the mountains and drainage sketches of the water-courses in the vicinity, and having taken angles to every prominent peak, bluff, and stream junction visible, we started for camp. The next morning found us on our way to the great San Juan country, of which we had heard so much and found out so little. Our course at first lay to the southwest, along the Ute trail, which leads from Los Pinos over to the Rio Grande. We ascended one of the peaks in the small group containing station 33 of the previous season, and had a good view of the deep and rugged cañons leading outward from the center of the mass. In the several succeeding days we made stations 3, 4, and 5 on the high plateau already mentioned. From this plateau we got the grandest view of Uncompahgre obtained from any station during the summer. The full height of the great precipice stood out in clear profile. Its striking resemblance to the profile of the Matterhorn gave us a wholesome dread of it, for as yet it had never been ascended by any one, and we felt that to reach the summit might be beyond the range of the possible. The plateau upon which we stood ranges in elevation from 12,400 to 12,700 feet above the sea, and covers an area of about fifteen square miles. We rode over it on our mules, to make the station, and found it covered with loose rock, which in some places was so rough as to necessitate long detours in going from one point to another. As in many other cases which occurred subsequently, we found this plateau covered with puddles of water, and wherever there was soil it was always boggy. On the west and north sides it was terminated by bluffs, ranging in height from 1,000 to 2,500 feet, the last 200 to 500 feet being nearly vertical. On the west side of the plateau the bluff terminates below in rolling, timbered land, which extends a little over a mile to the bed of Lake Fork. The total fall from the top of the bluff to the stream is 4,000 feet, in a horizontal distance of one and a half miles.

Having finished this part of the country, we traveled down the White Earth to the point at which it emerges from the upper cañon. Here the new road from Saguache crosses it at a small angle, and, swinging far up to the north to avoid the high bluffs, it finally turns up Lake Fork at a point about twelve miles from the crossing of the White Earth. Thence our course lay up stream, and we traveled along just west of our plateau stations and nearly under the bluffs. From a camp

just below the junction of Godwin Creek and Lake Fork we made station 8 on a point about five miles east of Uncompahgre Peak. The next station to be made was on the great peak itself. In order to accomplish this, it became necessary to move with our pack-train about five miles up Godwin Creek, to a point where it is joined by a small stream coming in from the north. Leaving the train at this point, and taking an extra mule with us to carry our blankets and food, we rode with great difficulty up the side gulch, and camped at an elevation of 11,900 feet, near the timber-line. We started out early the next morning, expecting to have a very difficult climb. We were terribly taken aback, however, when, at an elevation of over 13,000 feet, a she grizzly, with her two cubs, came rushing past us from the top of the peak. Contrary to all expectations, we found the ascent very easy, and arrived on the summit at 7.30 a. m., having been two hours and a half in climbing up 2,400 feet. We found that the bears aforesaid had been all over the summit of the peak, though how they got up over one or two short but steep passages in the ascent, puzzled us not a little. The summit of the mountain is quite smooth, and slopes from the brink of the great precipice toward the south. It is composed of several successive flows of lava, in horizontal position, which gives it a stratified appearance, and causes the slope to the south to appear terraced in profile. On the north the edge is sharp and definite, and the precipice so perfectly vertical, that by dropping a stone a few feet from the edge it fell 1,000 feet before striking an obstacle, as we determined by timing the descent. The bluff surrounds the peak on all sides except the narrow strip on the south end, and is about the same height all around, but not so nearly vertical as on the north side.

From here, for the first time, we were able to see the great massiveness of the mountains in our district. To the south the peaks appeared in great numbers, and in the distance appeared a group of very scraggy mountains, about which the clouds were circling, as if it was their home. Subsequently we found that they were most of the time thus enveloped. The high mountains near us covered the horizon from the east around by the south to the west. Nearly due west of us appeared a very high, sharp peak, which was afterward ascended as Mount Sneffels, and just to the south of it another high mass, bearing in its center a large, flaring patch of snow. The culminating point of this was, later, station 35, or Mount Wilson. Southeast of us, and about eight or ten miles distant, was a mass of peaks, filling the whole space between Lake Fork and Godwin Creek, all of a bright red color. The highest of these points is over 14,000 feet above the sea. Ten or fifteen miles to the southwest was another smaller mass of lower peaks of the same color, while in various places appeared mountains of white, yellow, and blue, all the colors being very well defined and clear. They were caused by the oxidization of iron and other ingredients of the rocks. To the north the mountains fall very suddenly down to the bed of the Gunnison; in fact, the peak is situated on the extreme north line of the Uncompahgre Mountains. Just before we left the summit, clouds came along, and we were soon enveloped. It was at this time that we experienced, for the first time in the season, the electrical phenomena which later interfered so much with the topographical work. As at this time these phenomena were not very marked, and as our experience on all the peaks was very similar, the detailed account of them is reserved for another place. We made the entire descent that evening from the summit to Godwin Creek, where the pack-train had left us, getting the benefit of a rain before reaching camp. Up to the second day before this the weather had

been very fine, but from this time till fall, rain commenced early every afternoon, and continued into the night. Moving up Godwin Creek. Dr. Endlich made a special examination of some of the highly-colored peaks already mentioned, while Wilson and I rode up to the head of the cañon and out upon a high and pretty extensive plateau, which extends from a high, sharp pinnacle a few miles west of Uncompahgre Peak around the heads of Godwin Creek and Lake Fork to the head of the Animas. It forms the divide between these three streams and the Uncompahgre River. An area of fifteen or twenty square miles is above the timber-line. Ten or fifteen square miles have an elevation of over 12,000 feet. The timber-line here ranges from 11,500 to 11,900 feet above the sea. This whole area is covered with a very short growth of grass, which is almost entirely unfit for feed for animals. This is common with all the grass growing high up on the mountains; it is not nutritious. Unlike the plateau east of Lake Fork, this is not surrounded by bluffs. Instead of being smooth and nearly level, like the former, it is rolling and cut up by gulches. The slopes down to the surrounding streams are steep, but bluffs are very rare. The ground is not very rocky, but like all the soil at this elevation, is very damp and boggy. A number of small lakes are dotted here and there over it, and in many places springs of ice-cold water gush out from the rocky prominences, fed by the banks of eternal snow which are scattered about in considerable numbers. In crossing this elevated region a strong west wind was blowing, and, the temperature being below the freezing-point, riding was very disagreeable both for our beasts and ourselves. Under these circumstances we were not so observant as we should otherwise have been. Still, there were so many new and interesting things about us that we could not fail to notice some of them.

The eastern half of the plateau drains out through a cañon leading northward and westward into the Uncompahgre River. We crossed its head on our tramp, and noticed that it fell very suddenly, till within about two miles of us it became a deep, narrow cañon, at which point the stream turned abruptly to the west. From this fact we were enabled to get a good broadside view of the north bluff of the cañon, and we saw it weathered out most curiously, being worn into almost all conceivable fantastic shapes, the general appearance being that of a great wall covered with niches and statuary. Time would not permit us to go closer and make a more careful examination; so we had to content ourselves with a distant view. From the headwaters of this creek we crossed a divide running laterally across the plateau, and for some distance the drainage was into Godwin Creek, until, near the peak upon which we made our station, the water again flowed to the north. From station 10 the cañon of the Uncompahgre River appeared in all its ruggedness. From here we got a fine view of Mount Sneffels and its surroundings. We could see no possibility of ascending the peak from the east side, as it was cut up by rugged cañons and innumerable bluffs and pinnacles; these latter ornamenting all the ridges leading down from the great peak and its near neighbors.

In some places numbers of the pinnacles massed behind one another presented the appearance of church-spires, only built after a much grander style of architecture than most of our modern religious edifices. In some places two systems of vertical pillars were separated by a narrow strip of horizontal lava-flow, and served to heighten the fantastic appearance of the rock-forms. The fact that we stood on a peak four or five miles distant from the scene described, will give some idea of the great size of these pinnacle-forms. A month later we had another much nearer

and finer view of this same curious group from a peak several miles southwest of us. Beyond this we saw nothing of interest that cannot be better described in the sequel.

The next day found us retracing our steps down Godwin Creek. After camping a night at the junction, we moved up Lake Fork, making a station by the way on a low point near the stream. A few miles above the junction we came to a beautiful lake bearing on Mr. Prout's map the name "San Cristoval." This is by far the finest of the many little lakes we saw during the summer. It is in the bed of the cañon, and has been formed by a slide from the east side of the stream. Judging from the growth of pines over this slide we concluded that it had taken place in very recent times, but how recent we could not determine. The lake is about one mile and a half in length, and in some places as much as a quarter of a mile in width. Several very small islets covered with willows add much to the beauty of the scene. A thick growth of pine timber surrounds it on all sides. To the east there is a tolerably easy slope back to the foot of the bluffs of the high plateau. On the west side the high mass of red mountains rises abruptly from the water's edge.

It was near the lower end of this lake that the Randolph party of artists discovered the bodies of five men the day after we passed them at this point. They are supposed to have been murdered by white men for their money. The cañon of Lake Fork is nowhere so rough as that of Godwin Creek, and the trail is quite good for the greater part of the distance to the head of the stream. After camping a short distance above the lake, and getting a good night's rest, we took an early start on one of the most curiously interesting and strangely dangerous trips of the season. We had to ride up the creek several miles before making the ascent of the peak for which we were traveling. From this fact we were thrown late and got caught on the summit in one of the afternoon storms. Intermingled with other unusual drawbacks, we had a fair share of the common but not less disagreeable climbing over loose rocks and through fallen timber; neither were events of the chase wanting to add to the great variety of incidents encountered during this eventful day. The object in view was to make a station on the highest point of the red mass above mentioned. In order to accomplish this, we had to follow up a ridge, along which patches of loose rock alternating with timber made the riding very difficult. It soon became impossible to follow the ridge any farther, and we had to cross the gorge on our left, going down 300 or 400 feet, and up again more than a thousand feet to the summit of the next ridge. Riding was out of the question, so we had to lead our mules. After getting out of the cañon the ground became smoother, and near the timber-line we rode along without difficulty, the land being very open and covered with grass. It was here that a considerable herd of mountain-sheep appeared in the distance. We saw them before they saw us, and, leading our mules out of sight, slipped through the timber with the utmost care; but before we could get in position the sentinel of the herd, posted on a prominent point, gave the alarm, and they all instantly took to flight. Wilson succeeded in shooting one on the run. As we had had no fresh meat for two weeks, the result of the shot was very gratifying to us all.

For the rest of the ride the ground was covered with a short growth of grass, but devoid of trees, as we had passed the timber-line. At an elevation of 13,000 feet the soil ended abruptly, and from that point on, all was loose rock. Here we hitched our mules to stones, and, taking the note-books and instruments, continued the ascent on foot. This part of our work was quite easy, although the height we had to climb was

nearly a thousand feet vertical. Before reaching the summit of the first high point on the ridge, we noticed stray clouds wandering up and down the neighboring cañons, as if only waiting for us to reach the top before commencing the attack.

Seeing that it would be impossible to reach the main peak before the storm would burst upon us, we made our station on the first point. The main peak is 41 feet higher and a mile and a half distant, being connected with it by a long unbroken ridge. Had time permitted, we should probably have occupied both points as stations, but we were unfortunately prevented from doing this by the peculiar circumstances to be described. Station 12, the southern and lower of these two points, is situated in the upper bend of Lake Fork, where, from flowing in a southeasterly direction, it swings around to the east. Near the base of the peak Lake Fork receives its principal tributary from the south side, which on Mr. Prout's map bears the name of Snare Creek. This peak is the most southerly of the red group included between Godwin Creek and Lake Fork. Its height is 13,967 feet above the sea. On the north and east sides the slopes are quite steep but regular, while on the south and west the sides are very precipitous, with a fall from the summit to the valley below of 4,400 feet in a horizontal distance of one mile.

On arriving at the summit, Mr. Wilson hastily made a rough sketch of the surrounding drainage, and then set up the instrument, while I proceeded to make a profile sketch of the mountains south and west of us. We had scarcely got started to work when we both began to feel a peculiar tickling sensation along the roots of our hair, just at the edge of our hats, caused by the electricity in the air. At first this sensation was only perceptible and not at all troublesome; still its strength surprised us, since the cloud causing it was yet several miles distant to the southwest of us. In the early part of the storm the tension of the electricity increased quite slowly, as indicated by the effect on our hair. By holding up our hands above our heads a tickling sound was produced, which was still louder if we held a hammer or other instrument in our hand. The tickling sensation above mentioned increased quite regularly at first, and presently was accompanied by a peculiar sound almost exactly like that produced by the frying of bacon. This latter phenomenon, when continued for any length of time, becomes highly monotonous and disagreeable. Although the clouds were yet distant, we saw that they were fast spreading and already veiled many degrees of the horizon. As they approached nearer, the tension of the electricity increased more rapidly, and the extent of our horizon obscured by them increased in nearly the same ratio; so that the rapid increase in the electric tension marked also an increased velocity in recording angles and making sketches. We felt that we could not stop, though the frying of our hair became louder and more disagreeable, for certain parts of the drainage of this region could not be seen from any other peak, and we did not want to ascend this one a second time.

As the force of the electricity increased, and the rate of increase became greater and greater, the instrument on the tripod began to click like a telegraph-machine when it is made to work rapidly; at the same time we noticed that the pencils in our fingers made a similar but finer sound whenever we let them lie back so as to touch the flesh of the hand between the thumb and forefinger. This sound is at first nothing but a continuous series of clicks, distinctly separable one from the other, but the intervals becoming less and less, till finally a musical sound results. The effect on our hair became more and more marked, till, ten or fifteen minutes after its first appearance, there

was sudden and instantaneous relief, as if all the electricity had been suddenly drawn from us. After the lapse of a few seconds the cause became apparent, as a peal of thunder reached our ears. The lightning had struck a neighboring peak, and the electricity in the air had been discharged. Almost before the sound reached us the tickling and frying in our hair began again, and the same series of phenomena were repeated, but in quicker succession, at the same time the sounds becoming louder. The clouds now began to settle into the Great Cañon of the Lake Fork, and boiled about in a curious manner; here and there a patch of cloud would separate from the main mass and move about by itself. In passing over a thick cluster of pines down near the bed of the cañon, the lower parts would get caught and drag through with the greatest seeming difficulty. The different parts seemed to be affected by different currents in the air, and at times two little masses of cloud would pass each other less than a mile apart, but would soon turn aside, or rise up, or lose themselves in the great cloud that pretty nearly filled the Great Cañon and its branches. At times a portion of the mass, moved by an upward current, would rise several hundred feet above the general level, and, the force ceasing, would topple over and slowly fall back and lose itself in the general mass. The whole moved about in a chaotic manner, producing a curious effect. When you consider that the top of the cloud was not less than 2,000 feet below us, you can form some idea of the strange scene that presented itself to our eyes in those exciting times. The clouds soon began to rise up and approach us. As they did so, the electricity became stronger and stronger, till another stroke of lightning afforded instantaneous relief; but now the relief was only for an instant, and the tension increased faster and faster till the next stroke. By this time the work was getting exciting. We were electrified, and our notes were taken and recorded with lightning speed, in keeping with the terrible tension of the storm-cloud's electricity. The cloud reached us, coming on like a fog, looking thin and light near us, but densely white at a short distance. All the phenomena before mentioned increased in force after each succeeding stroke of lightning, while the intervals between strokes became less and less. When we raised our hats our hair stood on end, the sharp points of the hundreds of stones about us each emitted a continuous sound, while the instrument outsang everything else, and even at this high elevation could be heard distinctly at the distance of fifty yards. The points of the angular stones being of different degrees of sharpness, each produced a sound peculiar to itself. The general effect of all was as if a heavy breeze were blowing across the mountain. The air was quite still, so that the wind could have played no part in this strange natural concert, nor was the intervention of a mythological Orpheus necessary to give to these trachytic stones a voice. Having completed a rough sketch of as much of the surrounding country as was not obscured by clouds, I hastily took up the mercurial barometer, hoping to get a reading before we should be compelled to leave the summit; but, alas! too late for success. The lightning-strokes were now coming thicker and faster, being separated by not more than two or three minutes of time, and we knew that our peak would soon be struck. As I took the barometer out of its leather case, and held it vertically, a terrible humming commenced from the brass ring at the end, and increased in loudness so rapidly that I considered it best to crawl hastily down the side of the peak to a point a few feet below the top, where, by lying low between the rocks, I could return the instrument to its case with comparative safety. At the same time Wilson was driven from his instrument, and

we both crouched down among the rocks to await the relief to be given by the next stroke, which, for aught we knew, might strike the instrument which now stood alone on the summit. At this time it was producing a terrible humming, which, with the noises emitted by the thousands of angular blocks of stone, and the sounds produced by our hair, made such a din that we could scarcely think. The fast-increasing electricity was suddenly discharged, as we had anticipated, by another stroke of lightning, which, luckily for us, struck a point some distance away. The instant he felt the relief, Wilson made a sudden dash for the instrument, on his hands and knees, seized the legs of the tripod, and flinging the instrument over his shoulder dashed back. Although all this occupied only a few seconds, the tension was so great that he received a strong electric shock, accompanied by a pain as if a sharp-pointed instrument had pierced his shoulder, where the tripod came in contact with it. In his haste he dropped the small brass cap which protected the object-glass of the telescope; but, as the excitement and danger had now grown so great, he did not trouble himself to go back after it, and it still remains there in place of the monument we could not build to testify to the strange experiences on this our station 12. We started as fast as we could walk over the loose rock, down the southeast side of the peak, but had scarcely got more than 30 feet from the top when it was struck. We had only just missed it, and felt thankful for our narrow escape.

We could not follow down the ridge we came up, as, in the present state of affairs, it was highly dangerous to cross any prominent point, even though it should be much lower than the peak itself. Hail and sleet began to fall freely, and as we descended to a lower level they were exchanged for rain, with which we were well drenched, even before reaching the mules.

We found Dr. Endlich waiting for us, having just returned from the ascent of a lower point of the main peak, where he had experienced similar phenomena to those already described, only differing from them in degree. He said he had seen the lightning strike our peak, and at first thought that we might have been caught, till finally he saw us coming down the mountain.

Our mules seemed glad to see us, not because they cared one straw for us personally, but because our arrival was the signal for the return to camp. Whether they had been pestered by the electricity, we could not tell, but they were doubled up into the most compact shape that mules are capable of assuming, and did not seem to appreciate at all the romance connected with a cold rain-storm at a high altitude.

Hastily putting on the saddles, we started down the mountain-side. By this time the clouds enveloped us entirely, and rain fell almost without intermission till long after we reached camp.

On our way we loaded one of the mules with the meat of the sheep killed on our way up, but as it was a very difficult matter to tie the whole animal securely across the saddle, it gave us a great deal of trouble, as in going down steep places it would slip forward, and in going through brush it would be pulled back. To go back the way we came, was such a very difficult task that Wilson concluded to take a short cut for camp, though this involved the risk of coming to bluffs or impassable slides. We had to lead our mules the whole way, which was very steep, and composed of loose rock mixed in among the thin, straight stems of the quaking-asp trees. Here and there we came to large patches of loose *debris* without any trees, and were compelled to fall

back and take a new tack. The rain was still falling heavily when the sun set and darkness commenced.

In these high altitudes there is scarcely any twilight, and darkness quickly follows sunset. I will not go through all the details of our descent, as nothing occurred beyond what has happened in the experience of every mountain-climber. We reached camp late in the night, thoroughly drenched, and had to eat supper in the rain, which was anything but pleasant.

If I could end the history of the adventures of this remarkable day by describing how we were pleasantly housed in dry, comfortable quarters, and how we contentedly "wrapped the drapery of our couch about us and lay down to pleasant dreams," I would. But, alas! how the romance would be taken out of the story if I should tell how we crawled into our low, short, and narrow little tents, with the water running under at the edges, and leaking through at the top, and how we had to lie as still as possible lest we might disturb the pools of water gradually collecting on our blankets, and precipitate them into the inner recesses of our bed-clothes. All this and more shall I leave untold, and cease to disturb the several members of the party, placidly snoring away in the babe-like innocence of their slumbers. And while they thus replenish their wasted energies with the nocturnal balm of sleep, may the unwearied mind of the reader wander like a restless ghost up and down this interesting cañon, and observe with care the high and picturesque walls of trachyte which extend from the creek-bed to the summit of ever-memorable station 12, and wonder, it may be, at the pine-trees scattered here and there in the cracks in the rock, 2,000 feet above him, having scarce a root-hold, and looking so diminutive as to suggest the idea that some Japanese had been there and applied their wonderful art to stunt them to their apparent pigmy stature. If, too, he extends his observations up the scarcely less imposing cañon of Snare Creek, he will find many more things wonderful in their nature, but too varied to find a place in such a hasty sketch as this. If the reader, after having satiated his curiosity with the many wonders of nature here laid out before him, will return from his wanderings to the camp he left the night before, an interesting scene will soon present itself to his eyes. If, a little before the break of day, he observe closely the tents of the several sleepers before mentioned, he will soon observe a movement in the one occupied by our huge black cook. That little circumstance marks the dawn of the next fiscal day, even though the first object emerging from the tent be as black as night. In all countries it is a recognized fact that the darkest part of the night comes just before the dawn, and the present case tends to confirm the truth of the adage. The morning is bright and clear, but all things not under close cover are wet, and wood is no exception to the rule. The cook searches about under trees and bushes till he has collected together an armful of tolerably dry branches, and then makes the fire. The fire burns, and another era in the cook's existence has commenced. He takes four sheet-iron pots, all of different sizes, and starts for the creek. A man of less muscle would content himself with two. He soon returns with all the vessels filled with water, and places some of them on the coals to heat, one for the coffee, the others for cracked wheat, hominy, or other articles. At this stage of the proceedings there is some commotion in another tent, and presently the two packers emerge from their cover fully equipped for the day. One immediately starts out to hunt up the mules, while the other puts the packs and aparejos in order. The cook proceeds to bake his bread in a Dutch oven, while the rest of the party still snore

on. In the intervals of his cooking he opens the mess-boxes, sets them about four feet apart, opens out the leaves, and, placing a support under the middle, spreads his cloth, and the table is ready. A short time before everything is ready he rings the first bell for breakfast, by yelling out, in the barbarous mountain dialect, "Grub pile!" or sometimes simply "grub," for short. At this there is great commotion, and the rest of the crew "pile out" in all sorts of shapes and in all states of nudity. They hurry, for there is no driver like hunger, and they now feel a yearning in the inner man that cannot be repressed, and their love of sleep itself gives way. A general rush for the nearest water soon takes place. In a few seconds all are washed, and immediately commence the attack on the breakfast-table. They make short work of it, and at 7 o'clock all are in their saddles and off.

Following the trail up the creek, we found it very rough, but at a point west of station 12 the bed of the cañon widened out, and from there our riding was quite easy. Leaving a notice on a tree near this place, for the train to encamp, we ascended a low peak to the south and west of the creek. From this point we succeeded in clearing up some points in the topography which had been unavoidably missed from station 12. Two miles west of it was a very high, massive mountain, with a great horizontal band of white running across the face of a high bluff on the northeast side of the peak. This mountain bears on the map the name of Handie's Peak, and was ascended the day after this as station 14.

From station 13 we had a splendid view of the red mass to the north and east, station 12 being the nearest of all the peaks. The last 2,000 feet in height was composed wholly of dull-red *débris*, with very few bluffs. Here appeared some of the finest mountain-forms any of us had ever seen. From our distance, which was several miles, the individual stones were all lost to the eye, and the slopes appeared as if they were made of red sand, but of course having the forms which naturally result from coarse *débris*. The tops of the ridges were nowhere jagged, but were invariably formed of gracefully-flowing curves, while mountain-lines could scarcely be more beautiful than the magnificent sweeps of the curves formed by the long *débris* slides. Except on the south and west sides of station 12, these curves were nowhere broken by any considerable bluffs. Having reached this station early in the morning, we were not troubled with storms during our work.

Several large silver-bearing veins crossing the ridge near this station gave us the first intimation of our approach to the mining region. We descended to camp, which we found just at the base of the peak, and arrived quite early in the afternoon. The next day, August 14, we moved up stream, leaving directions with the packers where to make camp. We rode up a small creek coming in from the south, which drains the basin between station 13 and Handie's Peak. The ground most of the way was very miry, and the brush and timber very difficult to pass through. After passing the timber-line, the only difficulties in our way were the boggy ground and rocks. One or two very steep slopes, along which we had to ride, were very disagreeable; but much less so for us than for the poor donkeys. At an elevation of nearly 13,000 feet we found a grassy patch of ground, which was large enough and level enough for our mules to stand on without much danger. Having secured them to the rocks, we climbed up the peak, which we found a very easy matter, as the total rise was scarcely a thousand feet and the slope quite gentle. A short distance below this summit, at an elevation of about 13,500 feet, we found some shallow prospect-holes sunk

on a vein which cut transversely across the ridge. As yet we had seen none of the miners, but these holes, with accompanying notices written on a stake, indicated their presence somewhere in the vicinity. We soon reached the summit of Handie's peak, and found it not near so acute as most mountain-summits in this region. This peak is very massive, with high bluffs on the east side, which continue along the east ridge around to station 13. Between the two stations is a deep basin, amphitheatrical in form. To the south and west the slopes are steep, but not precipitous.

To the west, and several thousand feet below us, we saw several little lakes of a bright emerald-green color. We had no opportunity to make any investigations as to the cause of the color, but from observations later in the season we concluded it must be due to vegetation at the bottom of the lakes. The white band already mentioned as appearing on the east bluff was found to be composed of volcanic ash. Here, again, we saw a band of sheep, but having left our guns at the mules we could not shoot them.

Early in the day we noticed the clouds hovering about the quartzite peaks, as we had seen them so often before. They never completely veiled all the peaks of the group, but early each day began to circle about them in a restless sort of a way, like so many mighty lions about their lair. To us this apparent restlessness suggested a consciousness of their terrific destructive power, which only awaited a mandate from the "God of storms" to be set in motion. We even now held those peaks in awe, as there seemed to be established somewhere in their midst a regular "manufactory of storms." Our subsequent experience among them never completely obliterated this idea. About 1 o'clock in the afternoon the clouds again came on, accompanied by hail and electric phenomena similar to that previously described. We could detect the electricity in the air long before the clouds reached us by holding our hands high in the air, when a faint clicking was audible.

The phenomena were precisely similar to those experienced on station 12, but having reached the summit earlier in the present case, we were able to leave before it became very dangerous. Just before leaving the top I slung the strap of the tripod over my shoulder, and experienced a sharp pain at the two points where the tripod touched me. Otherwise the phenomena were much the same as on the previous station. This peak is 13,997 feet above the sea, and 30 feet above station 12. After the hail and rain commenced, and fell incessantly till far into the night. The following day we crossed the pass from the head of Lake Fork to the Animas. The elevation of this pass is 12,540 feet. The ground up to that point is very boggy and the riding disagreeable. The rise in the last mile of distance is more than 1,000 feet. How the people of Saguache ever expect to bring a wagon-road up this I cannot see. On account of the surrounding bluffs there is very little opportunity to wind the road up it, while the miry nature of the soil will require vast sums of money to be spent after the grade is obtained before the road can be made passable. The fall from the pass down to the Three Forks of the Animas is very sudden. Leaving the train to proceed to Howardville, wherever that might be, we climbed up a peak on the north side of the trail. This point commands the headwaters of the Animas, and is 13,675 feet in height. We succeeded in getting a few of the most necessary details of the typography, but as we had traveled a considerable distance since morning, it was late before we reached the summit, and about the usual time the electric storms again commenced. By this time the romance connected with these phenom-

ena had all disappeared; and at this time and thereafter, whenever our hair began to fry, we generally disappeared at pretty short notice. We never waited again so long as we had done on station 12. As we were working on the peak, peculiar sounds reached our ears from the depths of the Animas Cañon, 2,500 feet below. They resembled very much the whistle of a locomotive when heard from a great distance. By listening carefully and looking through our glasses, we formed a shrewd surmise that this strange sound was the last indrawn note of the plaintive bray of the jackasses used by the miners in bringing the ore down from the mines. The harsh lower notes had all been dissipated before they reached us, leaving nothing but the refined essence of the sound behind. We considered this as a conclusive evidence of the presence of white men, and immediately descended to our mules. The trail down to the Animas was quite steep, notwithstanding it wound around a great deal. For the last part of the distance the fall was very sudden down to the Three Forks. The total fall from the pass is 1,400 feet in two miles. At what is called the Three Forks, or the junction of the three creeks which form the head of the Animas, we found several cabins with a number of miners about, who kindly showed us specimens of ore from their various mines. As Dr. Endlich will give a detailed description of the mines, I will refer the reader to his accompanying report. A very short distance below the forks, the great bluffs of the Animas Cañon commence, at first more or less broken up by slides and by gorges formed by streams from the mountains. A little while after leaving the forks the trail crosses the Animas, and follows across the great rock-slides which come down to the water's edge on the east side of the stream. These extend many hundred feet above the trail, and are terminated above by a series of high bluffs, one receding behind the other and separated usually by small *débris* slides, similar to the great one below; sometimes very steep grassy slopes form the connection between the bluffs. Above all, a long slope, more or less steep, connects the last and highest with the mountain-peaks above, which are from 3,000 to 4,000 feet above the stream-bed, but seldom ever visible from the trail, as the near precipices cut off the view. The bluffs on the west side are for a long distance much less broken than on the east, and instead of having slopes at their bases, rise abruptly from the bed of the cañon, in many places a thousand feet, nearly vertical. But the series of perfectly inaccessible bluffs often rise from 2,000 to 3,000 feet above the stream, and are connected with the mountain-peaks by steep grassy or rocky slopes. In some places the bluffs form the abrupt termination of what from above are seen to be sharp, rocky ridges, leading down from the peaks. In the upper end of the cañon the only gorge cut through the western wall is that of Eureka Gulch. Near its junction with the Animas this is very narrow, but a short distance back it widens out into a considerable basin. A very interesting thing in connection with these bluffs is the fact that many little streams run over the top and reach the bed of the cañon by a succession of little falls. These give a picturesque appearance to these otherwise bare bluffs. Still more important is their bearing on questions connected with the working of the mines. A fall of from 1,000 to 2,000 feet could be easily obtained. It can scarcely be doubted that there is a never-failing hydraulic power contained in these little streams sufficient to work all the machinery that can ever be brought into these mines. All that is required is to apply it properly. In making this general assertion, I do not refer simply to those streams which fall over the bluffs of the main cañon of the Animas, for it must be remembered that, up Cunningham, Arastra, and other gulches, there

are hundreds of other similar streams that can be used just as well, if not even better than these.

While crossing the great slide on the trail, we could see miners at work against the bluffs on the west side of the river. Curious-looking zigzag trails led up to these mines. Others were tunneling from the bed of the stream, and seemed to be in a poor position in case of a great spring-thaw, as all their work would then be wasted. At one place we saw an ice-bridge over the stream, which struck us as a novelty, for the middle of August, at an elevation of only 10,000 feet, in this latitude. At a point about five miles below the Three Forks the steep slide across which we were riding abruptly ended, and we came out into a thick clump of trees in which were several log cabins, bearing on a flaring sign-board the word "Eureka," evidently intended for the name of a town that was expected to be, though what had been found here to suggest the name was not immediately apparent. It is not impossible, however, that the first settler coming up the Animas here found his farther upward progress barred by the great rock-slide. At this point the bed of the cañon suddenly widens out to a quarter of a mile or more in breadth, forming the upper end of Baker's Park. A great portion of the level ground is here covered by willows and swale-grass, cut through and through by old beaver-ditches. After leaving Eureka, the ground is very uneven, and quite devoid of timber, except up the sides of the cañon.

The bluffs on the west side become more and more precipitous, and less broken up by gorges; while on the east the few bluffs which presented themselves farther up stream are exchanged for steep rocky mountain-slopes, with few bluffs. At a point about three miles below Eureka the Animas is joined by Cunningham Creek, a considerable tributary, coming in from the east side. Howardville, containing at the present time some eighteen or twenty log cabins, is situated on both sides of this stream near its mouth. This is the first settlement in Baker's Park, and among its other attractions can boast of a store, a butcher-shop, assay-office, shoemaker-shop, and post-office. Although as yet there is no regular mail-communication with the outside world, it is expected that a regular mail-route will soon be established by the Post-Office Department. All mail is now brought in from Del Norte by occasional travelers, and letters cost ten cents besides the regular United States postage.

From this position a splendid view of some of the silver-veins can be obtained. The face of the high bluffs, west of the town and across the river, is covered with a net-work of yellow veins, extending from the bed of the stream up as far as we could see. Later we found that these same veins cropped out on the other side of the mountain, individual veins being continuous the whole distance. We found some of them crossing the highest point of the ridge at an elevation of 13,500 feet, thus giving a vertical depth for the outcrop of 3,800 feet, while the horizontal distance was not less than the thickness of the ridge, a length of from three to four miles. How much farther they may have extended horizontally, we could not make out in our limited time.

At a point nearly west of Howardville the bluffs end, and steep grassy and rocky slopes take their place and continue to the lower end of the park.

On August 16, the day after our arrival at the town, we crossed the river and ascended a peak northwest of Howardville, but not quite visible from that place on account of the intervening bluffs. The slopes were all grassy, but so steep that we could ride but a small part of the dis-

tance. We came upon the top of the ridge near a little sharp point on the spur, which I believe is the one designated by the name of "King Solomon's Mountain." Just a little below the top of this point we found a level patch of ground about 20 feet square, where we concluded to leave our mules, as such level places seemed to be rare in this vicinity. Looking about, we saw only one stone of sufficient size to hitch our animals to, and that was an oval one; but as no alternative presented itself, we tied the ropes of the two mules together, and then fastened them as well as we could to the stone. The result of this will be seen on our return.

The main peak was about half a mile to the north of us, but as the ridge was easy to walk over, we had little difficulty in reaching the top. On this peak we made station 16. Its elevation is 13,541 feet, as determined from the mean of twenty-three readings with a mercurial barometer. This point is not very sharp, but is simply the culminating point of several rocky ridges. From here a splendid view of the vicinity of Baker's Park may be obtained, although only a small part of the park itself is visible. In order to understand rightly the situation and peculiar position of this very interesting park, it will be necessary to give now a general description of it, leaving the minor details to be filled in in our future travels. From this point we can see nearly the whole of the great depression of which Baker's Park forms the most important part. Just to the east of us the Animas runs along, its deep cañon nearly 4,000 feet below our present position, but the high bluffs bordering on the west succeed in completely hiding the stream from view. Howardville is also shut out from the sight by the same obstruction, although it almost comes within the field of view. The fall from the summit of this peak to the stream near Howardville is 4,000 feet in 9,500 horizontal. Just across the river, Galena Mountain has a fall to the Animas of 3,700 in a horizontal distance of 7,000 feet, while down to the nearest point on Cunningham Creek, the fall is 3,500 feet in 5,000 feet horizontal. On the southwest side of Cunningham Gulch the fall is even greater than this. These cases are not unusual specimens, but I have selected them because the peaks are well known and can be easily found on the map. I could instance many others where the fall was full as great and even greater. From station 16 we had a good view up Cunningham Gulch, from the fact that the continuation of the direction of the stream passed almost exactly through the station.

Along the east side of the Animas a line of high peaks extends, from its head down to the lower end of the great cañon, a distance of thirty miles. At the north end of the line, but draining into Lake Fork, is Handie's Peak, with an elevation of 13,997 feet. Next come two nameless peaks, the first having an elevation of 13,830 feet and the second 13,770 feet above the sea; then Galena Mountain, with an elevation of 13,290 feet, and next, Mount Kendall, 13,380 feet above sea-level. Below this for some distance lower points continue the chain, till we come to the group of quartzite peaks, ranging in height from 13,600 to 14,054 feet, where the line culminates in Mount Æolus and Pidgeon's Peak, and, falling off suddenly to the south, soon loses itself in the plains of Southern Colorado and New Mexico. The great and important feature of this region is the far-famed Baker's Park. Small in area and quite unimportant in itself, it would be utterly disregarded if situated in other parts of Colorado; but, located as it is, surrounded on all sides by the most rugged mountains in the Territory, if not in the whole Rocky Mountain system, this little area of flat land becomes an object of curiosity and interest. When looked at as the center of the great mining

district, it becomes an object of great practical importance. But not till one has crossed over the several passes leading out of it can he feel a proper regard for this little spot, so carefully guarded by nature from the invasion of man. In itself, it is nothing more than the bed of the deep cañon of the Animas, spread out at the lower end to a width of a mile or two. It extends from the little town of Eureka, already mentioned, down the Animas to the base of Sultan Mountain, a distance of about nine miles. It is divided into two parts, the upper of which is contained between Eureka and Howardville, a distance of about three miles, and is quite rolling, so much so as to be scarcely worthy the name of park. Below Howardville the cañon again contracts till within about three miles of the base of Sultan Mountain, when the cañon-bed widens out into a beautiful level piece of land, about three miles long, in the direction of the stream, and having a width of from one to two miles. It contains, in all, from 2,000 to 3,000 acres. This is the true Baker's Park; but the division between the two portions, as we have described them, is not important, and in nature not well defined. The wide part above Howardville tapers almost insensibly into the narrow part below it, but the line between this narrow part and the true park below is quite definite.

The new town of Silverton, at present containing about a dozen houses, is situated near the center of the level area, on the south side of Cement Creek, a stream flowing into the Animas from the west, and passing through the park. Bounding Baker's Park on the south is Mineral Creek, which, flowing from the west, highly impregnated with iron, sulphur, and other ingredients, hugs closely the foot of Sultan Mountain, and joins the Animas near the entrance of the lower or Great Cañon. Almost all the water in this country is as pure as any in Colorado, but this stream is so strongly impregnated with mineral ingredients as to be quite unfit for drinking. The elevation of Silverton is 9,400, and of Howardville 9,700 feet. From our present position, looking down the valley, it seems to be completely closed up by Sultan Mountain, and the exit of the river is not visible. At the lower end of the park the Animas swings around toward the southeast, and for about seventeen miles cuts a most terrific cañon, ranging in depth from 2,000 to 4,500 feet in depth, through quartzite rock almost as hard as steel. It might have been expected that in the beginning the stream would have selected its course somewhere near the junction of the trachyte and sandstone with the quartzite. It seems, however, to have been turned by some agency another way, and so cut its course through the harder rock this long distance, without being at any point more than three miles distant from the softer material.

In order to get a true conception of the isolation of Baker's Park from the rest of the world, a thorough understanding of the passes leading out of it is necessary. First, let me say that the ruggedness of the Great Cañon below the park is such that travel through it must long be a matter of great difficulty, though it is said that some miners have passed up from the plains on the south into Baker's Park by that route. The trail at present most traveled by persons passing between Baker's and Animas Parks crosses over the southeast slope of Sultan Mountain. At the divide this trail has an elevation of 10,460 feet, but the highest point is several hundred feet higher than this. This route is the roughest and most dangerous of any leading out of the park, and even in the best summer weather is unsafe for pack or riding animals.

The next pass is the one on the southwest side of Sultan Mountain, which has an elevation of 11,570 feet above the sea, and, though not

dangerous like the preceding, is very disagreeable, from the bogs, fallen timber, and rock-slides which beset one's way. Another is the Bear Creek Pass, leading from the head of Bear Creek to the head of the San Miguel, on the west side of the mountains. Its elevation is 12,600 feet. On the east a long stretch of fallen timber in a bog, through which the trail passes, makes travel very difficult. On the west a great rock-slide, over which the trail leads, is scarcely less disagreeable. Two passes lead over to the head of the Uncompahgre River, but, as the box-cañon of the latter bars all egress, they require no description here. To the east of our present position are the two passes at present mostly used by persons passing to and from the mines. The first, from the head of Lake Fork to the head of the Animas, having an elevation of 12,540 feet, has been already described. The other, the pass from Cunningham Gulch to the Rio Grande, has an elevation of 12,900 feet at the highest point of the trail. Over this has passed almost everything that has been brought into the park. The trail is very steep, and in the best weather is muddy, and after a rain it becomes perfectly horrible. When it is remembered that the height of a great part of the park is only 9,400 feet, it will be seen that the ascent from the valley to each of the five passes at present used will be, in feet, as follows: 1,300, 2,200, 3,200, 3,140, and 2,690. This gives some idea of the way this little valley is isolated from the outside world. This, then, is the far-famed park, named after that daring leader of his little band, who lost his life within its bounds. This is the *cul de sac* into which he and his men were mercilessly driven by the Indians in 1862. How many fell in the massacre, how many starved or froze to death, seems even yet to be veiled in mystery. But how the present survivors ever escaped might well remain a mystery when we consider the great depth of snow that must then have covered these high mountain-passes, and that, at that date, the country was perfectly unknown. From our station 16 only the lower end of the park, including Silverton, is visible. The view of the mountains, however, is very extensive, all the high peak stations made up to this time being plainly visible, except the first one south of Los Pinos agency. Mount Sneffels stands out boldly, about fifteen miles to the northwest of us, while about an equal distance to the east of us appears the high peak, called, from its shape and location, the Rio Grande Pyramid. Just a little east of south the quartzite peaks again stood out in their peculiar ruggedness. From this point we also had a good view of Arastra Gulch. Its upper end is a rocky amphitheater, between 12,000 and 13,000 feet in elevation. In its center was a little lake. At the lower end of the amphitheater there is a very abrupt fall of from 1,000 to 2,000 feet down to the bed of the creek.

Having reached the summit of this peak unusually early, we had plenty of time to study the topography carefully. Just as we were finishing up the work of the station, and had commenced building a small monument out of the few stones in the vicinity, the well-known tickling sensation about the roots of our hair again commenced, and we could see its cause in the shape of a heavy rain-cloud which was slowly drifting up the cañon. We could see long dark streaks extending from the cloud to the valley below, indicating heavy rain. All rain-storms in this country, when seen from a distance, present this appearance. A continuous mist-like connection extends from the cloud to the earth, but through this are streaks much blacker than the rest. To a person unacquainted with those storms, these streaks would appear as bands of vapor, a little thicker than the rest. In truth, however, the part that seems like thin mist is heavy rain, while the black streaks are almost

unbroken streams of water. These are what are usually known in the mountains as water-spouts. We left the summit before the electricity became very troublesome, but the rain which followed we could not avoid. Packing up our books and instruments, we walked down to the place where the mules ought to have been, but where, to our amazement, they were not. Looking over the ridge, we saw the mules, still hitched together, standing on the steep east slope, about forty yards from the summit, but the round stone was nowhere to be seen. A heavy furrow through the snow-bank, near the top of the ridge, with several deep indentations in the soil below, told a curious tale. It seems that as the storm came on, a strong cold wind arose from the west, which, with the accompanying rain, made the mules feel very uncomfortable, as they were on the west side of the ridge. In order to better themselves, they moved over to the other side, slowly dragging the stone after them, till, reaching the brink, the steep slope animated the otherwise inert stone with a considerable power, and it in turn took the mules in tow. Of course, as soon as they found themselves pulled they drew back, but, finding the stone inexorable, one of them moved up a step and found herself relieved of the strain, and commenced nibbling the short grass to be found in this vicinity. But what one gains the other loses. The whole weight of the stone now pulls on the second mule; but it is not in the nature of the beast to resist for a long time a steady and unrelaxing strain when unaccompanied by swearing. She moves a step forward, and, finding relief, goes to grazing. The first by this time has forgotten all about the stone, and, finding herself suddenly jerked, her whole asinine obstinacy is aroused, and she braces herself for resistance, but after a minute or so, finding the pulling force unaltered, and hearing no oaths proceed from the stone, she slowly comes to the conclusion that this is not a human contrivance, and moves up. Thus by slow degrees the stone pulls them down the slope, over the little snow-bank and some distance beyond, disputing, of course, each step of the way, for such, alas! have we too often found, to our sorrow, to be the nature of the beast. After reaching a short distance from the top of the ridge, the rope evidently slipped off the stone, and the latter, rolling faster and faster, could have found no obstruction to its course for full 3,000 feet down the mountain. What the mules themselves thought of their mysterious leader they never revealed; nor did we wait long in the cold rain to hear their story, but hurriedly putting on the saddles, dragged them down that mountain much faster than the stone did; but they moved on joyfully, for they knew as well as we that they were going to camp and to grass. Their shriveled forms and backs, curved up when we first found them, indicated clearly the fact that they were disgusted with the country, especially all of it above 13,000 feet in elevation. The rain now fell in torrents, and the grass being thoroughly wet, the walking was very disagreeable, but the slope was very steep and riding on our tired beasts very slow, so we walked most of the way and dragged our mules after us. Reaching Howardville, Mr. Wilson found that the expected supplies had not arrived, so he concluded to finish the piece of country east of Howardville and down the Rio Grande as far as might be convenient. The next day, August 18, we started eastward up Cunningham Gulch, up which a well-marked trail leads over to the Rio Grande. This is by far the most interesting of the secondary cañons of the Animas system. After passing the main bend, which is about two miles east of Howardville, the side-slopes become steeper and steeper, and finally end altogether in becoming nearly vertical bluffs. These are nearly, if not quite, as high as those along the upper course of the Ani-

mas, already described. On the west side, these bluffs are rather more precipitous than on the east, and come down closer to the stream-bed. These consist usually of a series of bluffs one above the other, receding from the view. Over the last tier, which is from 1,000 to 2,000 feet above the stream, numerous small streams of water pour, and passing over the succeeding bluffs in falls and cascades present a beautiful spectacle. In the early spring, when the snow is melting and they are swollen to considerable streams, the sight must be magnificent. A number of mines are located high up the slopes wherever they are not too steep to be ascended. Here and there a little low hut is visible on the east slope. Near the head of the gulch the trail is very muddy and badly cut up by travel. The upper part of the cañon ends abruptly with steep, high bluffs on all sides, except the narrow strip up which the trail winds to the pass. Several lodes are located at the head of the gulch. The amphitheatrical form of the head of the cañon with the great bluffs are very characteristic of volcanic formations, and all over the San Juan region they are the rule rather than the exception. Nevertheless, the sudden termination here of the great Cunningham Gulch is exceedingly interesting. The stream falling over these bluffs serves to heighten the effect.

The trail now leaves the creek and ascends the east slope. It is very steep and always muddy and slippery. The grade may be appreciated by calling to mind the fact that from the bed of the stream to the pass the rise is about 1,500 feet in one and a half miles horizontal.

The incessant travel over this trail by the miners, with their horses, mules, and burros, keeps it in a bad condition. Although it can scarcely be said to be dangerous, still its slipperiness adds much to the labor of the already overwrought beasts of the miners. The really bad part of the trail is only a small part of the whole distance. On the summit the ground is gently rolling, and the trail passes between low hills which form the principal part of the country in the immediate vicinity. The elevation of the pass above the sea, as determined by a single reading of the mercurial barometer, is 12,090 feet.

We made station 17 on a table a short distance southwest of the pass. From this vicinity a good view of a number of the most rugged of the quartzite peaks may be had. Those that appear range in height from 13,600 to 13,800 feet. After camping overnight on the head of the Rio Grande, the next day we made station 18 on a peak between Pole and Lost Trail Creeks, whose elevation is 13,656 feet. From this peak we had a good view of the country south of Lake Fork. In this vicinity are scattered a number of pretty high peaks, but they are generally isolated from each other, and have none of the massiveness of the mountains about the head of Lake Fork and the Animas. In ruggedness they cannot compare with many that will be described further on. To the east the slopes begin to be more gentle, and at a distance of a few miles appears a pretty extensive plateau surrounded by high bluffs. The next day, in passing down the Rio Grande, we noticed a very peculiar formation consisting of a very bright-green-colored rock weathered into little needles and spires. It is situated against the south side of station 18. After camping near the junction of Lost Trail Creek with the Rio Grande, we made two stations on the high plateau, just to the east of the camp. The climb was very difficult on account of the great masses of fallen timber we encountered and the bluffs that came in our way. Once on the top of the plateau, the riding was very easy. It was covered with loose rock, (trachyte,) but not so much so as to seriously impede our course. There being no prominent point, we were compelled

to make two stations. No. 19 was made on the eastern part of the north edge, No. 20 on the west. This plateau may be said to cover about five square miles; the elevation of most of this is over 12,000 feet. The eastern part slopes off quite gradually, while on the northwest and south the plateau terminates in nearly vertical bluffs which in many places are several hundred feet in height. To the east of this the ground becomes more and more even, till at a distance of about fifteen miles down the river Bristol Head rises abruptly to an elevation of 12,800 feet. From this position it appears in profile. From station 2, a series of high plateaus extends southward all above timber-line, and ranging in height from about 11,500 at the lowest point, a few miles north of Bristol Head, to about 13,000 feet, near station 2. Southward from the lowest point, the plateau slowly rises till, after culminating in the bald summit of Bristol Head, it falls suddenly 4,000 feet down to the Rio Grande, and so terminates. From station 19, a grassy slope, which we afterward found to be Antelope Park, seemed to extend to the bluffs of Bristol Head, but after looking with the field-glasses we saw that a cañon intervened. But look at it as much as we would, there was a peculiar appearance about it we could not then explain. From station 20 we had a splendid view of the Rio Grande Pyramid, which was eight miles distant, and across the river from us. This is probably the finest view that can be had of this beautiful mountain. Its pyramidal form is almost perfect, while at the same time there is just enough bluff intermingled with the *débris* slopes to give relief without the usual accompaniment of coarseness.

We left the plateau quite early, as we had a long distance to travel before reaching camp. The pack-train, according to orders, had traveled up the creek which comes into the Rio Grande from the south, a little below the mouth of Pole Creek. We proceeded without delay to follow them. At first the riding was quite easy. We passed several salt-licks, which were tramped full of tracks of deer and mountain-sheep. Soon the cañon narrowed in and traveling became very difficult. We found no trails, tracks, or signs of any kind to indicate that anybody had ever gone up the creek before us. At several points the traveling was very dangerous; at one place that I now recall to mind it was especially so. The creek at that time was a considerable stream, and, from the great fall it had, was a perfect torrent. The bed was filled with large stones, and among these the water boiled and foamed terribly. At this point we had to slide our mules down a very steep, rocky slope of about 100 feet in height; at the bottom there was scarcely room enough for a man to stand conveniently between the slide and the stream. Just above this point was one of those deep pools where the big trout love to dwell, while at its lower end the water rushed through between several large rocks like a mill-race. Now the only way to cross was just at the lower end of the pool, where the water was shallow; below, the current was dangerously swift; above, the water was 6 or 7 feet deep. Leaving the mules and instruments with me, Wilson scrambled across to the other side, and I threw him his mule's rope, and while he hauled I whipped the beast behind. After a few minutes of this treatment, with the asinine obstinacy for which this particular mule was famous, she leapt out into the pool and, swimming up to the head, tried to climb up a smooth, wet rock, but did not succeed. After a thorough stoning she finally returned to me, and we repeated the experiment, this time with better success. Next, my mule, "Bones," was taken in hand. Having passed through the valley of humiliation the year before, and probably having taken mental notes on the disgraceful failure of her

comrade's first attempt, she "made the riffle" with little trouble. Other experiences of a little less exciting nature served to heighten our dislike for this creek. Having climbed over 2,000 feet in the morning, and made two stations, we felt very tired, and our mules walked slowly. After a while darkness began to come on, and camp did not appear. "Bones" began to take on that pitiful look engendered by her horror of having to stay out. Every time that such a contingency seemed probable her lower lip would fall and hang down in a strangely sorrowful way. She seemed to recall that awful night in the Greenhorn Mountains, in 1873, when she slept out away from her companions, and where, after several months of unceasing labor, that one night broke her down and made her lip hang down as it never hung before and never did again. Soon, however, we came again upon the tracks of the train, and her long ears pricked up and she became so excited over it that I could scarcely keep her in a walk. When the camp-fire appeared and she got the scent of her companions, she seemed perfectly happy and contented, as we were also. For some distance below camp the stream-bed had widened out into quite a little valley, which continued above camp up to the head of the stream.

The next day, August 22, we made the ascent of the Rio Grande Pyramid. The day was beautiful to its close, a remarkable circumstance for this season of the year in these mountains. As we were camped at the foot of the mountain we had plenty of time. Wishing to give the mules a little rest, Mr. Wilson directed Ford, one of the packers, to follow after and bring them back to camp. We rode up the west slope of the mountain to near 13,000 feet elevation. Taking off our instruments, we threw the stirrups over the saddles, and fixed the bridles and ropes so that they could not get caught in the timber. We then tried to start the mules back to camp by throwing stones at them. They would move off a little, but if we tried to drive them farther they would dodge back. The reason seemed to be that they had noticed that camp always was made in a different place each day, and they were afraid of getting lost if they strayed off. Their great horror of getting lost was very noticeable in many cases. In every case where we had to hunt for the camp after dark, they seemed to give up entirely and put their whole trust in their riders. Often have we left them loose, at elevations ranging from 12,000 to 13,000 feet, far above the timber-line, but they never attempted to stray away, although they would crop whatever grass they could find near. At times when they could not be tied so as to get enough grass, we would take off saddle and bridle, and leave them perfectly lo se, but it seemed to make no difference.

The climb on foot was quite easy, and was not more than about 1,000 feet vertical. On the top we found a nicely-built monument of stones, which we increased in height to about 6 feet. Some enterprising climber seems to have taken a just pride in leaving his mark on this beautiful peak. The fact that the monument was on the true summit indicated the fact that its builder was something else than a common miner. The height of this peak (station 21) is 13,773 feet above the sea. The view from here is very fine. The whole mass of the quartzite peaks, so often mentioned as prominent features in the views from previous stations, from here stand out clearer than from any point yet visited. Almost all of the higher points are clearly visible, but they are massed together in such a way that from this point the drainage of the system cannot be made out at all. In one place, to the south of us, we could see low rolling country, indicating that we were near the southern termination of the high mountains. To the

east the view was very extensive, many points of the Sangre de Cristo range, east of San Luis Valley, being clearly visible at a distance of one hundred and ten miles. In the descent nothing of special interest transpired. The next day camp was moved up near the timber-line, at the head of the creek, while the three of us followed up a branch coming in on the east side, and, crossing the national divide, made station 22, on the southern point of a granite ridge, at an elevation of about 13,000 feet. The divide here is very near the boundary between the trachyte and quartzite. This line marks a sudden and decided change in the nature of the topography. Station 22 is on granite, the first we had yet come across in the district, but it only appears here in a small area. Before leaving we were again visited by an electric hail and rain storm, which soon cut short all work. Although surrounded by high peaks, rising several hundred feet above us, the phenomena seemed quite as marked as at any previous time. The whole mass of peaks west of us was soon veiled in clouds. Just as we were leaving the little knob on the end of the ridge which had formed our station, we all felt a heavy shock as if from an electric battery. Being unaccompanied by thunder, we concluded that we had been subjected to a miniature stroke of lightning. This is the last station where we felt any electricity, although we were often caught on the peaks in rain and hail storms. The next day we had a storm almost exactly similar to this one, only it was entirely unaccompanied by electricity. The date of this station (station 22) was August 23. The rain continued falling during our ride to camp, which we found located in a clump of pines, at the junction of two small streams. Like all the trees near the timber-line, these had few branches, and furnished us little protection from storms.

Next morning the sky was pretty clear, so, without moving camp, we crossed the divide south of us, and ascended the high quartzite mountain east of the Vallecito. This quartzite rock is very hard, and breaks off in angular fragments with almost polished faces. Where *débris*-slides are formed of these fragments it is found that the rocks slip and slide on each other very easily. Sometimes we would step on a stone weighing several tons; it would tip up, as if delicately balanced, or slip from under us. These seem to be universal characteristics of quartzite *débris*, so that in climbing over it great care is required. This peak was very steep and difficult to climb; in fact, more so than any which we had yet ascended. When we had nearly reached the summit, and at an elevation of 13,600 feet, a small grizzly bear suddenly jumped up a few yards in front of us and rushed down the steep slide on the south face of the peak. Of course, in a climb as long and difficult as this, our instruments and books were all we cared about bringing with us, and for this reason our guns were left behind. We were much surprised to see an animal in this place. It is ever thus; when you feel you are treading a path never trod by a living thing before, and your imagination begins to build for itself a romantic picture, if some such vile, worldly thing as a paper collar or a whisky-bottle does not intrude itself on the sight, some beastly quadruped needs must break the precious solitude and scatter your airy castle to the winds. To show our utter disgust for all animate things that could not live below this altitude, we yelled and threw stones after the bear till he finally was lost to sight far down the mountain-side. In our hate we even wished he might have been in a position whence we could have rolled rocks down on him. As we passed on we saw several places where he or others of his breed had scraped out beds among the finer *débris*. They seemed to have come up here for fresh air, or to sun themselves, or both. After this experience we named the

peak Mount Oso, from the Spanish word for *bear*. As we neared the top of the peak the clouds coming from the west began to touch the summit, and we expected that the electricity would prevent any work. As we came up into the cloud we felt no electricity, at which we were much surprised. Setting up the instrument, we worked for about an hour, getting sights through the clouds, for as yet the storm had not fully commenced. The height of this point is 13,640 feet.

A number of sharp, distinct peaks, all quartzite, rise up in this vicinity from 2,000 to 4,000 feet above their bases, and all are very steep and rugged, more like needles than mountains. A number of little lakes are dotted here and there at the heads of the cañons. To the west, across the Vallecito, the view into the high quartzites was much obstructed by clouds. To the northwest, at a distance of about six miles, in the center of the group, was a high peak of vertical strata, and all the upper portion formed of great vertical pillars of quartzite. It seemed to be on the center of upheaval, as on the two sides of it the strata inclined in different directions. Its elevation is about 13,783 feet.

In the immediate vicinity of our station the strata dipped at every possible angle, and appeared so complicated that only a very detailed study could ever bring order out of the chaos.

In our descent from the peak we got pretty thoroughly drenched, and found our mules looking disconsolate. We had left them near the second little lake northeast of Mount Oso.

Crossing the pass near this lake, we passed over to our camp on Rio Grande waters, encountering much miry ground on the way. The rain continued falling steadily all day and all night. The next morning the creek near our camp was flooded, as were also our little tents. Rain continued next morning, and as the elevation of this camp was 11,600 feet, and the timber thin and scattering, it was a poor place to remain during a storm. We remained in camp all day. By standing in the rain before the log fire we succeeded in drying ourselves nearly as fast as we got wet. Hoping that it would clear off, we did not start early the next morning, but seeing no prospect of a change in the weather, we saddled up early in the forenoon and departed for other scenes. Our supply of provisions was getting very short, and we could not remain longer. All our flour had already given out, while the dried apples, beans, and even the bacon were beginning to draw to their close. With all these solemn facts staring us in the face, the caravan started about 10 o'clock a. m. Our course lay up the creek and over the pass we had crossed the day previous. We found the whole country flooded. Naturally very boggy, the ground was now so full of water that it almost floated.

The next morning the rain still continued. As the supplies were getting short so fast, we concluded to strike the nearest way for Howardville. Moreover, we were getting disgusted with this part of the country, and wanted to find a better camping-ground. Accordingly, we moved up the main branch of the Vallecito. It was running considerable risk, as without a trail to guide us we felt doubtful about being able to cross the divide. The rain fell fast, and we were soon soaked to the skin. The grade being very steep, we rose in elevation very fast, and soon found snow and rain falling together, and we nearly froze. We stopped at one place and made a fire by which to warm our feet, but the wood was so soaked with water that we found it a difficult task. The train was behind and did not catch up; so Wilson and I heaped all the logs that were lying handy upon the fire, and, as we found later, the rest of the party made good use of the fire. Near the head of the creek the slope became very steep and rose up to the divide, which, at the point at which we

crossed it, was nearly 13,000 feet in elevation. A keen, strong breeze did not serve to add to our comfort in our present saturated condition. While waiting here for the train, Mr. Wilson made station 24 on a point east of that where we crossed the ridge. The elevation of this place is about 12,700 feet—a little higher than the point where we crossed the same divide a few days ago. We traveled down that branch of the Rio Grande which heads between stations 24 and 25, and camped in a splendid grove of pines. In the afternoon the sky had begun to lighten up. Isolated clouds passed swiftly over us from the west, ever and anon cutting off the sunlight, and producing the sudden chilling effect always noticeable in the shadow of a cloud at high altitudes. The great difference of temperature in the sun and in the shade at these altitudes is very remarkable. At this particular time I thought I noticed that whirls and gusts of wind always accompanied the fast-moving shadow. Whenever a long space between clouds allowed the sun to shine unobstructed, for some time the air would be quite still, but the next cloud-shadow seemed to bring with it little whirlwinds and changing gusts of chilly air. By the time we had unsaddled our animals the sun was shining brightly, and now, after four days and three nights of incessant rain, we had a good opportunity to dry our clothes and blankets, and every one made good use of the short time before sunset. In the evening, instead of sitting down to a hearty meal, we had to make our supper on bacon and dried apples alone, and very short rations at that. We had a few beans left, but all the bacon and apples were used up for supper; but as we expected to reach Howardville the next day, we did not mind it very much. Our bill of fare next morning presented only two articles—beans, which on account of our elevation could not be well cooked, and sugar. We could take either or both as we chose. Beans with other food are very strengthening, but alone we could scarcely eat them at all. The pack-train started direct to Howardville, while Wilson and I climbed the most northern of the quartzite peaks, a point having an elevation of 13,576 feet above the sea. The day was clear, still, and beautiful. After riding as far as we could, we still had about a thousand feet to climb on foot over the steep *débris* slides before reaching the top. We soon discovered that our breakfast of beans and sugar formed a poor foundation for such hard work. Once on top, a row of ten distinct peaks stretched in a nearly east and west line before our eyes. Their ruggedness may be understood from the illustration of "the Quartzite Peaks from station 38," the three or four on the left of the picture being just in front of us from station 25. Being much nearer, they appeared much more rugged than from station 38. The peaks in this row range from 13,560 to 13,831 feet in elevation. Between them we could see the higher peaks to the south.

The great and essential differences in the topography resulting from the change in the geological formation is here so very marked and is so interesting that I cannot pass it by without notice. The general difference in the appearance of the country in trachyte and quartzite formations is intended to be shown by the two large topographical sketches presented in this report. The view of Mount Sneffels from station 29 shows nothing but trachyte rock, while the sketch from station 38 shows quartzite only. But a mere sketch cannot show well the characteristics of the two. I have tried to work out some of the features peculiar to the topography of each of these two formations. These being derived almost wholly from observations in Southern Colorado and for the great part in this particular region, they may not have a very general application.

First, then, in trachyte or volcanic rocks, the lava-flows being for the most part horizontal, the rock fractures vertically, and the falling away of pieces produces bluffs which are generally very nearly vertical. Moreover, from the nature of the flow, horizontal lines or bands are left running across the faces of all the bluffs. This latter is very characteristic of the formation.

Second. At the bases of the bluffs *débris* slopes commence, and sweep down generally in graceful curves to a greater or less distance.

Third. These slopes are seldom very steep for any great distance, the great fall from the mountain-summits to the valleys being by way of high bluffs and comparatively gentle *débris* slopes. In other words, the total fall is very irregularly distributed over the distance from the top to the base of the mountain.

Fourth. The junction-line of the bluffs and *débris* slopes is almost always distinctly marked.

On the other hand, in quartzite formations—

First. Bluffs vertical, or nearly so, are very common; except in very rare cases there are no marked horizontal lines.

Second. The junction between the bluffs and *débris* slopes is never so distinctly marked as in trachyte.

Third. On account of the fact that this rock breaks off in large angular fragments, and also on account of its great hardness, it will lie at a much steeper slope than the other rock. From the same causes the loose rock does not take on those beautiful sweeping curves so common in volcanic rocks, but have a certain stiffness of line.

Fourth. The solid rock, from its great hardness and the manner of its crystallization, is often found in very steep, yet quite irregular slopes, without taking on the form of bluff. A noticeable instance of this is the most easterly of the ten peaks mentioned above. The fall from its summit to Vallecito Creek on the east is 3,000 feet in less than a mile horizontal, or a mean slope of nearly 32°; yet it is a plain slope of solid rock, more or less irregular, of course, but having no bluff in all that distance. On the north side of the same peak there is a slope at an angle of 60° to 80° for not less than 2,000 feet, yet there is no part of it bluff.

Still another point is the fact that in the metamorphism of the original sedimentary rocks into quartzite, the great natural convulsions attending that process have distorted the strata terribly, so that, as in this particular region, a number of peaks in a small area may each have its strata dipping at a different angle from all the rest. The effect of this on topography may be seen in the sketch from station 38. The high peak next to the last one on the left shows in a marked manner that the strata incline to the right, or southward. The high peak near the middle of the sketch, being in the center of upheaval, has vertical strata, while those farther to the right incline to the north. This latter fact is not so well shown in this sketch, but from some other points of view it appears very plainly. These facts show how the form of the peaks may differ in the same kind of rocks; but as there is little or none of this upsetting of the lava-flows, there must result a distinct type of mountain-form for each. The peculiar crystallization of the quartzite has also a marked effect on the forms.

In accordance with these facts, we find that quartzite mountains are generally much more rugged, but lacking the relief given to those in volcanic regions by the contrast of the bluffs with the *débris*-slopes. The boundary of the quartzite on the north follows closely the national divide.

On our return to Howardville we rode across the rolling ground which extends southward from Cunningham Pass. Arriving at the town, we found Mr. Jackson, the photographer of the expedition, with his party. He had just arrived from the Los Pinos agency. We made the ascent of Sultan Mountain with him, and he succeeded in getting a number of good photographs of the surrounding country. From this point is obtained by far the best view of Baker's Park that is obtainable from any peak in the vicinity.

After getting our supplies we marched up Mineral Creek, while Mr. Jackson struck south over the trail which passed around the west side of Sultan Mountain, and made a very interesting investigation of the old ruins in Southwestern Colorado.

In the afternoon rain fell, and continued into the night, but the next morning was cold and the sky clear and beautiful. This date (September 3) is remarkable as being the time of the abrupt change between summer and fall. After this, till the snow-storms commenced, the weather was cold and clear. Having camped overnight at the junction of Bear and Mineral Creeks, the next morning we moved up the latter, and made stations 27 and 28 on a high ridge between Mineral and Cement Creeks. Camping near the head of the creek, the following day we crossed the pass at its head and passed over to the head of the Uncompahgre River. The elevation of this pass is 11,100 feet above the sea. It is entirely covered with timber. The slope to the south is quite gradual, but to the north, down the Uncompahgre, the fall is 800 feet in two miles. Then for several miles the stream flows comparatively smoothly, till it finally enters a deep box-cañon, where the fall is very great. Traveling for some distance is both difficult and dangerous. At the bottom of the first steep slope a great area of fallen timber commences. The logs so cover the ground that traveling is very nearly impossible. Leaving a notice for the pack-train to camp near the beginning of this dead timber, Mr. Wilson, Dr. Endlich, and I rode on, and finally got through the timber, when we had open grassy ground to travel over, but the slope was so steep that we could ride only a small part of the way. Leaving our mules loose, as usual, to find what grass they might at this elevation, which was a little less than 13,000 feet, we made station 29, on a round-topped peak, which, being surrounded by peaks higher than itself, is of no great importance. It was taken as a station, because its position between two of the main branches of the Uncompahgre made it a key-point for the drainage system which forms the head of that stream. Its elevation is 13,206 feet. From this point we got by far the best view of Mount Sneffels, and the curious pinnacle-forms in its vicinity, which have already been mentioned as seen from station 10. The accompanying illustration, taken from a hasty topographical sketch, will give a faint idea of the great peak and its vicinity. Of course the elevation and ruggedness of the mountains shown in the sketch can only be appreciated by a person who has climbed many mountains. Even then the air is so clear at these high altitudes that one is deceived in spite of himself with regard to distances. From here we could see no feasible route by which to climb the great Mount Sneffels, so we laid the question aside till a view from some peak farther to the west should solve it satisfactorily. Next day we retraced our steps over the pass and down Mineral Creek, camping again at its junction with Bear Creek. Moving up the latter stream, we camped on a considerable branch which comes in from the north. This is probably the finest camping-ground on the whole stream, with fine timber, good water, and a sufficient quantity of grass. Above this

there is a dense grove of timber, through which you pass up a pretty steep slope; in a short distance the pines end, and you come out into an open space, extending several miles up the stream, and covered with a remarkably rich growth of weeds and shrubs. This circumstance is probably explained by the fact that here a great part of the lower slopes of the cañon is composed of red sandstone, which seems to produce a much better soil than the volcanic rock.

The next day (September 6) we made the ascent of the highest peak in this vicinity. It is marked station 30 on the map, and has an elevation of 13,897 feet. The climb was difficult, on account of the long slopes of loose *débris* up which we had to climb. The top of the peak was remarkable for its smallness. It is formed of two knobs, about 20 feet apart, the northern one being a little the higher, and connected with the other by a very sharp ridge. To the west was a slope of 60° or 70° for 30 to 40 feet, then a precipice of about a thousand feet nearly, if not quite, vertical. When the tripod was set up, we could not pass around it, but had to crawl under it. We three monopolized all the sitting and standing room on the peak. Mr. Wilson with the instrument completely covered the true summit. Dr. Endlich took his geological notes from the lower knob, while I sketched, sitting at the edge of and almost under the instrument. The slopes, on all sides but the narrow path we had followed, were very steep, and in a few feet terminated in great precipices. From here we got a splendid view of Mount Wilson, which we had seen from many stations before this, but always across the group of mountains of which station 30 formed a part. Now it rose up grandly, forming the most massive of any peaks in our district, and, judging from its appearance and rough estimates from the angles of elevation, we felt that it must be very high. In line with the peak, but several miles nearer, appeared Lizard's Head, a peculiar pinnacle, which from this view appears quite broad. It will be more particularly noticed farther on.

After finishing our observations, we built a small monument of loose stones, which, when finished, covered the top so completely, that a person could not pass around it. We descended more easily than we had ascended, and found camp at the lower end of a long patch of timber, near the junction of the main stream with the last tributary which comes in from the south as you travel up. This marks the upper end of the open, weedy area already mentioned. The total climb from our last night's camp to the station was 4,000 feet, and the descent to our present camp 3,200 feet. On the day following we let camp remain where it was, and rode up the creek to the south of us, and over the divide, to Engineer Mountain. On the way we had to pass around a peculiar amphitheater, which had been eroded out of the red sandstone. The stratification of the sandstone had produced benches, which extended all the way around the head of a little stream which flows into Cascade Creek. We found the ascent of the peak not very tiresome, but rather dangerous. We climbed up the ridge from the east. On our right was the great bluff, which is nearly a thousand feet in height and almost vertical. On the southeast side the rock weathered off in small plate-like fragments, producing innumerable cracks and little shelves, but none large enough to give a secure foot-hold. The slope on this side is very steep, so that if a person should slip he could not possibly save himself from destruction. Mr. Prout in 1873 ascended this same peak from the south side, which I should judge is much the safer, but at the same time the longer and more tiresome way. From this point we had a splendid view down the Animas. Animas Park was visible, and

the low country in its vicinity showed us that the high mountains were nearly at an end. A group of pretty high peaks were to be seen to the southwest, called the La Plata Mountains. They are completely isolated from the main mass of the range by many miles of comparatively low land.

On our return to camp a sudden and heavy shower of rain came up, but cleared off soon after. The next day found us on our way through the patch of timber already mentioned. The trail passes through the center of the group, which is very swampy, and our animals mired many times before we got through. We found relief only at the timber-line, after which we rode on, over grass and fine rock-slopes, up to the pass, which has an elevation, according to our aneroid barometers, of 12,600 feet. It is certainly the highest of all the passes leading out of Baker's Park. A pass which I think will be found much better, crosses the range about six miles to the northeast of this. To go this way you must travel up the largest tributary of Mineral Creek, which comes in from the west, and cross over on to a tributary of the San Miguel. This pass is not less than a thousand feet lower, and, at least to the west, has a much better grade. Passing over from Bear Creek to the head of the San Miguel, after a sudden descent of several hundred feet, we came to a small lake. Further down, the slope was more gradual for some distance, till we came to a steep *débris*-slide, down which the trail led to the valley below. The fall from the pass to the valley, by way of the trail, is 2,800 feet in two miles. On the east side of the pass the rise from the stream-junction, where we camped, to the pass is 2,000 feet in two miles.

Station 30 rose up boldly just to the north of us as we rode down the trail. Its side was worn out into beautiful forms, and the delicate blending of the dull red and yellow colors of the rocks, taken together with the long sweeps of the *débris*-slides, gave this peak a finer appearance than any we had yet seen. Once down in the little valley below, we found trees and grass growing very luxuriantly.

The trail crosses several boggy places, over which our mules passed with difficulty. A few miles down stream from the head of the little valley is San Miguel Lake, a very beautiful sheet of water, filled with fine trout. We stopped to make a compass station on the edge of the lake, and took a reading with the mercurial barometer, which makes the elevation 9,720 feet. Thence we traveled down the San Miguel River, along a very old, disused Indian trail; in some places, considerable trees lying across it showed that it had not been used for many years. For some distance below the lake, the San Miguel, which is here a pretty large creek, flows quite gently; but further down the slope suddenly increases, and the stream is broken up into falls and cascades. In going down the trail, at this point, we found the slope so steep that we had to dismount and lead our mules, till we reached the bed of a large creek which comes into the San Miguel from the east. After crossing this the trail ascends the north slope of the cañon, which is quite steep. The total fall, from the lake down to the junction of this creek with the main stream, is about 900 or 1,000 feet in a distance of two and a half miles. At least 600 feet of this fall takes place in the last mile. At the bottom is a fine fall, which from a distance we judged to be not less than a hundred feet in height. After crossing the cañon of the creek above mentioned we came out on a pretty smooth area, covered with scattering timber and fine grass. One thing very peculiar about this particular part of the country is the deathlike stillness that almost oppresses one in passing through it.

There is the finest growth of grass I have ever seen in Colorado, with beautiful little groves of pine and quaking asp scattered about, which one would expect to be full of game. The old trail and the very antiquated appearance of the carvings on the trees, and the absence of all tracks, old or new, indicated that the Indians had abandoned this route long since. With all these conditions, so favorable to animal life, we did not hear a bird twitter in the thickets, and saw neither deer, elk, nor antelope, nor even a single track of one of those animals. In all other parts of the country little squirrels and chipmunks were seen in abundance; but here, if they existed at all, they kept themselves close. We made camp on the large east fork of the San Miguel, just across the stream from station 32 on the map. The next day, September 9, we made station 32, on a low hill on the north side of the creek, which from its width might more properly be called a river. Above this for several miles the stream bed is very flat and covered with willows, while the stream itself winds like a great snake. A short distance below our station the stream plunges down very abruptly into the cañon of the San Miguel, which, above and below this junction, cuts down from 800 to 1,000 feet into the sandstone which here makes its appearance.

Leaving station 32 on our way to Mount Sneffels, we followed the trail a short distance, and then, turning off to the right, with great difficulty succeeded in descending to the bed of a creek flowing from the northeast. In this vicinity we saw a band of six gray wolves, the first we had seen during the season.

With great difficulty we followed up the cañon, which gradually became narrower and more rocky. In some places we had to cross over short spaces of smooth, almost polished rock-surfaces, inclined toward the stream. In one such place a small rivulet of water flowed over the surface and terminated below in a fall of considerable height. The smooth stone, thus wet, rendered our passage with the mule-train very hazardous, as the least slip would have resulted in the certain destruction of an animal, and possibly serious injury to members of the party. As we traveled upward the trees became more and more scattering, and the huge rock-slides, which below we had only seen high up against the mountain-sides, began to extend their fingers, like glaciers, far below the timber-line, and in many places reached the bed of the creek. These slides, ever and anon crossing our path, rendered travel very difficult for animals; the more so as they were composed of large angular fragments, often many tons in weight, and containing in their interstices no vestige of soil or vegetation. Sometimes we were able, by filling in the spaces with small stones, to form a rough trail over these. At others, we were able to go around them.

The obstacles to our onward march continued to grow greater and greater till we came to the upper verge of a clump of trees, and found our further progress completely barred by the great *débris*-slides on both sides of the creek, coming down to the water's edge, making the passage for animals an utter impossibility. About half a mile farther on we could see the trees commence again; but this strait, if we may call it such, was too much for us. Besides, we could see no prospect of good grass for the animals ahead, while this last group of trees formed a beautiful camping ground, and was overgrown with a rich crop of grass. There, then, we made camp; and as it was early in the afternoon, and the sun shining brightly, we took this rare opportunity of spreading out our blankets to dry. Wilson turned out his mule with the rest to feed, and walked on over the rock-slides, up the cañon, to reconnoiter, and after a long and tiresome walk reached the summit of the pass at

the head of the gulch, and saw, far across, a curious sink-like amphitheater, the object of our journey, looming up in terrible blackness before him. He saw at a glance that from our present position the peak must be ascended in one day, from our present camp, all on foot. The mountain had to be climbed, and the only easier ascent was from the north. But to get to that side of the mountain necessitated a circuitous journey of several days around the portion of the mountains jutting out to the west.

On his return to camp in the evening he reported the result of his deliberations to the rest of the party, and it was concluded to make the ascent from our present camp. We all knew well that the winter-storms would soon commence, and we could ill afford to lose the time necessary to go around to the north side of the mountain. The present camp is marked on the map as camp 45.

ASCENT OF MOUNT SNEFFELS.

The next morning we provided ourselves with lunches, as was our custom, and the three of us set out on foot at six o'clock, with our note-books and instruments. The first portion of the climb to the pass above mentioned, was in a northeasterly direction from camp. After crossing the portion of *débris* already described we came again to timber, then to soil covered with very short grass but devoid of other vegetation. After leaving the timber we could see about us, and a dreary sight we saw. Near us was nothing but these great angular fragments of trachytic rock, which, in the distance, faded to a dull, dreary, gray tint. In some places these slides formed long, regular, slightly curved lines; in others the stone appeared in swells like sand-dunes. The head of the cañon was amphitheatrical in form, like almost all in lava regions. On the east side we noticed particularly a sub-amphitheater, which, being composed of nothing but the loose *débris*, variegated by neither shrub nor blade of grass nor even barren soil, nor by any change of color in the rock, presented one of the most desolate sights that meets the eye of the mountain-climber. The weird stillness of high altitudes, only served to heighten the appearance of desolation about us, and gave one the idea that all nature was dead. Passing from the small area of soil over which we traveled after leaving the timber, we came again to the loose *debris*. Take note of that little patch of soil, for we may not step on soil again till we return at night from our tiresome climb. We now had to walk over the loose bowlders, stepping from stone to stone. This was very tiresome, as we could not relax our attention for a single moment for fear we should step on a balanced stone, and fall or slip on some smooth surface. Toward the last, the ascent became very steep, and we had to climb with great care. The last few hundred feet was just about as steep as loose rock would lie. We thought nothing of this, however, as we were fresh, and knew, besides, that this was the easiest part of our day's journey. We reached the pass at last, and as we had been climbing till then in the shadow we were glad to see the sun rising clear and beautiful. Everything seemed to conspire to make a beautiful day, and we lacked only time to let our imaginations run on and make a sublimely-romantic picture of sunrise at a high elevation. The claw-marks on the rocks, on either side of the summit of the pass, showed that the grizzly had been before us. We gave up all hope of ever beating the bear climbing mountains. Several times before, when, after terribly difficult and dangerous climbs, we had secretly chuckled over our having outwitted

Bruin at last, some of the tribe had suddenly jumped up not far from us and taken to their heels over the loose rocks. Mountain sheep we had beaten in fair competition, but the bear was "one too many for us."

After stopping a few moments to draw our breath, we had a little leisure to look around us. Looking back we could see the clump of trees, 3,000 feet below us, in which camp was situated; while in front of us, and behind us, and around us, appeared nothing but miles and miles of loose rock, with rocky peaks everywhere. Immediately in front of us was a curious depression, which, at its lowest point, was about 2,000 feet below us, although we were standing on the lowest point of the ridge surrounding it. It covered several square miles in area; it seemed to be completely closed up, as no outlet could be seen. It was apparently walled in on all sides. On our right a bluff ran clear around to the great mountain, and was very nearly vertical for full a thousand feet, at some points more. For three miles from this pass, along the ridge on the south side of the amphitheater, no point is less than 13,500 feet in elevation, while several peaks rise above 13,700, and one above 13,800 feet. Just to the south of Mount Sneffels was another comparatively low gap, which we felt was passable for good foot-climbers. This and the pass on which we stood were the only visible outlets; excepting these two, which were only just passable to men on foot, we could see no break in the great Chinese wall around this little empire of desolation and death-like stillness. We knew, of course, that there must be an outlet, and we knew where that outlet must be, but we saw none; we knew that the wall around the south side from us to the great peak, was continuous, and we could see that there was no break in the north wall for a considerable distance. The only point we were not sure of was at the northeast corner of the basin, just west of the peak. We were certain the outlet must be there, merely because we knew it could be nowhere else; however interesting it might have been from a geological point of view, it made our hearts sink within us to look at it. In making the ascent of a mountain, there is nothing more painful than to find a deep gorge or sink crossing your path; you know that all the distance you go down must be climbed up again before you reach once more your present level. We did not remain on the pass long enough to think half that I have written, for it has always been a maxim with us that every minute saved in the morning brings us back to camp so much earlier in the evening, and we can never tell how long a climb is going to take us. We find sufficient time while climbing to observe the scenery around us in a very general way, but the romance of our work is not fully appreciated by us till we reach civilization, where we can find leisure to think over what we have seen; at the time no romance is visible.

Almost due east of us and across the sink, at a distance of three miles, was Mount Sneffels, the end and aim of our labors. We traveled over the sunken area a considerable time, as it is several miles across. As we went on, it became more and more evident that the "fallen-in" appearance of this depressed area was not mere appearance. Evidence presented itself on all sides to prove that this great area had actually sunk in one mass several hundred feet. After a time the descent became much steeper, and we were much surprised on looking back to see behind us a peak rising up to a considerable height. The truth was, that it was only a ridge the same height as the main part of the amphitheater, and only presented the appearance of a peak from below. Near this point we were joined by Ford, one of the packers, who had concluded that he wanted to climb a peak, too, and had chosen this one, the hardest climb of the season. The lowest point of the amphitheater was the head

of a cañon leading out to the north. In the bottom of this was a small lake with an elevation of nearly 12,000 feet. It was rather a pleasure than otherwise when we began to ascend again. Now we were sure that we had no more gorges or sinks to cross, but that, excepting the ups and downs common to all peaks, our way lay upward. A few hundred feet above the bottom of the sink we came upon a bench on which were two small lakes, while just beyond, the steep, rugged mountain rose up. The first half of the height was very steep, but neither so tiresome nor so dangerous as the last half. The first was a plain slope extending from the lakes to the ridge of which the peak formed the termination. After reaching this we had to follow the sharp ridge of the mountain, which for a considerable distance was notched much like a comb. The crystallization was nearly vertical, and we could not follow along the highest line of the ridge, but had to go down the spaces between the teeth of the comb, then climb hand over hand up the steep bluff beyond, and so on until, within a few hundred feet of the top, the rock suddenly changed and was worn into more or less rounded slopes, all considerably polished, but beveled out in a curious manner, by the weather. These slight bevels were our only foot-holds, and, as the slope was quite steep in some places, we had to climb with care; but all our labor was soon rewarded by the glorious view which presented itself to us when we reached the top. On the west and north sides the peak was precipitous, while on the east it sloped much more gradually. It was situated on the extreme north edge of the range, and fell in very steep slopes to the low valley of the Uncompahgre, to the north. On all sides but this we were surrounded by rugged peaks and impassable cañons. The great fact which was instantly impressed upon our minds was the great area of the surface above timber-line. In fact, toward the east, south, and west, with the exception of a clump here and there, at great intervals, no timber was visible. Leading from the southeast side of the peak was a cañon, which, for a considerable distance down, ran nearly due east, but continually veering more and more toward the north. For several miles down, the slopes to the bed were very gentle, and presented the appearance of a deep hollow rather than that of a gorge; but it became more and more rugged toward its mouth, till finally, within a few miles of that point, it was almost impassable, till at last it joined the truly great cañon of the Uncompahgre River. This latter cañon and its vicinity is one of the most curious places in the district. The ridges running down to it both from the east and west sides are curiously notched and cut into strange shapes. Numerous high, sharp pinnacles, clustering together here and there, appear like church-steeples, while in other places the weathering of bluffs has produced the appearance of niches with statuary. We noticed several large quartz veins which seemed never to have been discovered by the miners. Across this space, and far above it, we saw Uncompahgre Peak, which showed us the familiar precipice on the north side, with the terraced slope on the south. Though presenting to our eyes the same profile as when we were approaching it from the east, we had lost much of our awe of the mountain from the fact that we had found so many that were harder to climb. We could see distinctly every station we had been on, so far, this summer, besides many of the year previous. The group of quartzite peaks stood up as boldly as ever about thirty miles to the southeast. In fact, I may state here that we have never yet seen the group from any station (and we have viewed it from all sides) without feeling both deep respect and awe for their terrible ruggedness. The fact already stated, that the storm-clouds seem to hover about them before

starting on their meandering ways, only served to add to our other feelings one of uneasiness. It may be that the vivid recollection of a long and dreary storm encountered in that region, made it appear to us in an exaggerated form. A little nearer, and slightly to the left of them, we could plainly see and distinguish all the peaks surrounding Baker's Park and the great mining region. Still nearer, and seeming almost under us, was station 28, with its associates, in the little cluster of deep red-colored peaks along the water shed, between Mineral Creek and the Uncompahgre. The view directly south of us presented the greatest mass of peaks to be seen in any direction. In that direction we look longitudinally along the range of peaks which forms the west line of the great mountain-mass, from which there is a very abrupt descent to the western plateau system. Chief among these stood station 30, which we had visited only a few days before, while about nine miles to the west of it was the high peak which we were soon to climb, but whose top was veiled in clouds, only the massive base and a few of the subordinate peaks being visible. West of it were several low, sharp peaks scattered here and there, but these soon sloped off into the plain, which extended to the horizon, broken only by the deep cañons which have been cut in the red sandstone by the streams. Directly to the west, in the far distance, was the group of the Sierra La Sal Mountains, and scattered about the horizon, south of them, we could see several very distant mountains, which were so far away that their blue color could scarcely be distinguished from that of the sky. Immediately to the north of us, and far below us, was the valley of the Uncompahgre, which, on both sides, seemed to have quite a gradual slope toward the stream. To us, viewing it from this great elevation, it presented the appearance of being covered with a rich growth of grass, though of this fact we could not be sure from so great a distance. The junction of the Uncompahgre with the Gunnison was distinctly marked by the vegetation along the banks of the two streams. We could see the course some distance below the junction, but it soon faded into the distance, and no one could say, from what he saw, what way the water had gone.

Beyond the Gunnison, on the north, there appeared a very elevated plateau, which, commencing near the mountain-peaks, presented a nearly horizontal profile for a considerable distance, and then, slowly increasing, its slope fell off almost insensibly to the west. Still farther around to the right, and about northeast of us, we could see most of the great peaks west of the Arkansas River. Many others appeared behind, but we did not trouble our minds about recognizing them, as all our time was necessary for the more immediate details of the topography around us. The great length of time required to ascend and descend again prevented us from remaining long. We had reached the top about noon, and found that we could not possibly remain over two hours and expect to get to camp; and since there was not a stick of timber on the way we dared not sleep out, even though the work on the peak had to be cut short. Our time being up, we raised a monument of loose stones about five feet high and started for camp.

The descent to the lakes was very easy and did not require much time, but, as we expected, the climb up to the pass again began to tell on us, and a weakness in our legs showed what a terrible strain on our systems the morning's climb had been. We finally reached the pass just in time to see the sun setting. Some may suppose that now we sat down and rested ourselves before making the last descent down to camp. But all frequenters of the high mountains are acquainted with the fact that there, darkness follows sunset very suddenly, with scarcely any twilight between. By calling to mind this fact and estimating the obstacles

between us and camp, we found that with our utmost endeavors we could not hope to get into camp till long after dark. On the other hand, we knew that we could not travel any considerable distance over the *débris* after dark, so we struck for the timber with all our speed. When darkness came on we found ourselves in a mixture of vegetation and loose rock, and had to pick our way with the utmost care. Our long-continued exertions were at last crowned with success, and we had the pleasure of sitting down to a supper which tasted to us far better than the most costly meals of civilization, served up in the most expensive hotels. We reached camp at eight o'clock in the evening, having been fourteen hours from camp, twelve of which had been occupied in steady climbing, and two in work on the summit of the peak. During those twelve hours we had climbed up 7,000 feet, and down an equal distance, beside traveling a horizontal distance of six miles, the whole over loose rock.

The next day, which was September 11, we retraced our steps down the creek, and turning to the right followed up the west branch of the same stream. We made station 34, whose elevation is 12,997 feet, on a peak at the head of this creek. It is the most western of the great group of mountains of which Mount Sneffels is the highest point. From here Lizard's Head, east of Mount Wilson, stood up like a high monument on the top of a mountain-peak. From this view the width of the base bears about the same relation to the height as in the great artificial monuments. The height of the column is 290 feet, and the elevation of the summit above the sea 13,160 feet. From this point it is fourteen miles distant in a straight line, yet it loomed up finely. On our way to camp, which we found located at the junction of the two creeks, we saw a black bear, the first we had yet come across, but he disappeared so suddenly that it was impossible to get a shot.

We were well satisfied with having finished this part of the mountain country. Only one peak of which we had any dread remained yet to be ascended, and that was Mount Wilson. From various circumstances we had reason to believe that this was higher than any station we had yet made, and from its rugged appearance we dreaded its ascent not a little. We returned to Lake San Miguel by the same trail we had come. On our way we saw a few cranes, which, with their long legs and unearthly noises, only served to add to the funereal aspect of the scenery. At the lake Dr. Endlich and I stopped to make a detailed sketch of station 30. From here the peak, with the lake in the foreground, and the rich groups of pine and aspen, separated by spaces covered with a rank growth of grass for a middle distance, presented a beautiful appearance. Crossing over the divide between the San Miguel and Dolores, at an elevation of about 10,200 feet, we turned off to the right and camped on a stream which flows down from the southeast side of Mount Wilson. On the way Mr. Wilson succeeded in killing a fair-sized male grizzly with his Springfield needle-gun.

September 13 was devoted to climbing the great mountain. Riding to the timber-line, we sent our mules back to camp by one of the packers, and commenced the ascent. At first we had a low bluff of slate to get over. The plates of the stone were remarkable for their great size and freedom from cracks. Above this the climb was quite easy for a considerable distance, being nothing more than plain slopes of loose *débris*. When we had reached an elevation of about 13,000 feet, we noticed three mountain-sheep on the top of a high ridge to the north of us, and about 1,000 feet above us. We could scarcely see how they got up there, such was the ruggedness of the ridge. They watched our

progress from this elevated stand-point with great interest, now and then jumping upon a rock to get a better view. They reminded us very much of some of the illustrations in the school geographies. A little farther on we came to a large steep snow-bank, up which we climbed with difficulty, cutting notches in the snow for foot-holds. At the upper end of this we came to what was much worse, very steep and dangerous rock-walls. From this point to the summit the stone is crystallized into vertical blocks, broken up so as to be very insecure. Near the beginning of this part we came to a notch in the narrow ridge which was filled in by a great stone, with its upper part wedge-shaped. On the east was a fall, very nearly vertical, of two or three hundred feet, terminating below in the steep snow-bank already mentioned. On the west was a precipice many hundreds of feet in height. Over this wedge we had to pass by straddling it and sliding ourselves carefully across. The whole distance was not more than ten or fifteen feet. It seemed very much like crawling along the comb of the roof of a very high house. Just beyond arose a steep rock-wall of loose shelving rock, up which we climbed with great difficulty, from the fact that all the rocks were loose; and even the largest could not be surely depended on. Reaching the summit of this we had to walk for forty or fifty yards along the sharp ridge over loose blocks of stone standing on their ends. The ridge was so sharp that we had to follow the center. On either side the slopes were so nearly vertical that if a person should once slip there would be nothing to stop his descent for many hundred feet, and in some places a thousand feet or more. All the stones were so loose that we could feel them move under our feet. For a part of the distance we had to walk straight, without anything to lay our hands on. At one point in particular, we had to leap across a break in the ridge where a stone had fallen out, trusting to Providence for the firmness of the new foot-hold. This was at an elevation of nearly 14,200 feet. We came very near giving up here; but we could just get a glimpse of the main peak a little farther on, and the temptation was too strong for us. After getting over this very dangerous part, we came to a deep crevasse which cut across the ridge, and succeeded, with great difficulty, in getting down to the bottom of it. A thin coating of ice over many of the stones, remaining from a recent hail-storm, added greatly to the danger of the climb. Thence we had to climb around the edge of a bluff, which we found a very dangerous undertaking. Once over this we climbed out of the crevasse without difficulty and gained the longed-for summit. We found it composed of the same rock as I have described, crystallized in vertical prisms, but crumbling away. Beyond a space probably eight or ten feet square, we could not pass without the very greatest danger of being precipitated over the terrible bluffs surrounding us on nearly all sides. We could scarcely find space enough for a monument, with room enough to pass around it. We did, however, leave a small monument of loose stones to mark this station, (station 35.) The thermometer stood at 33° Fahrenheit, which, with a steady breeze from the west, did not add to our comfort, especially as we had to confine our movements to such a small area. While we were up here clouds began to come from the northeast directly toward us and against the wind, apparently moved by an undercurrent, as they were below us. We could trace distinctly the track of the slight snow which fell the last night, by its marks on the peaks of the great mass. This peak was a splendid point for a station, giving the key to the drainage and topography for miles around. To the east and north the San Miguel and its tributaries appeared to us, from our

elevated stand-point, as if laid down on a map. Lizard's Head, a few miles east of us, formed a very prominent feature in the landscape, although, looking at it from our elevation, (14,280 feet,) its height did not show. From this direction it appears quite broad, from the fact that its greatest length is from north to south. To the west of us and quite near was a pretty high mountain. Beyond it were scattered a number of sharp, isolated peaks, mostly under 13,000 feet in elevation, while still farther to the west extensive plateaus reached to the horizon. In the far southwest appeared several very dim, bluish mountains, probably considerably over a hundred miles distant. Somewhat nearer to us, and a little farther around toward the south, appeared Ute Peak, near the southwest corner of Colorado. In the far northwest the Sierra La Sal Mountains were distinctly visible. Much was also seen that has been already described as having been seen from other stations. Mount Wilson is the highest mountain in Southwestern Colorado, and by far the most massive.

The descent was made with great care, and, luckily, without accident either to ourselves or the instruments. The descent over the snow-bank was much easier than the ascent, being accomplished by simply sitting down on the snow and letting gravity do the rest. Below it, we found several holes among the loose rocks, which bears had pawed out for beds, but we met none of the animals themselves. We reached camp quite early. The total height climbed on foot was 2,500 feet. It was not very tiresome, but by far the most dangerous of all the climbs of the summer.

After this we marched a short distance down the Dolores and made stations 36 and 37. After that, returning by way of San Miguel Lake, we recrossed the Bear Creek Pass, and camped at the creek junction, where we had camped a week previous. The day after, we rode to Howardville. We had scarcely got our dinner, when Mr. Jackson and party came up from their trip to the ruins, of which they gave glowing accounts. On September 19 we started down the Animas, crossing, over the southeast slope of Sultan Mountain, by the trail. We found the trail very bad. At one point a tree-stump stood in it. Some miners passing over this route a few days before had one of their animals killed by its falling down the side of the mountain at this point. The divide is about 10,460 feet in elevation, but the highest point of the trail is several hundred feet higher. We camped near this latter point, and the next day left the train to follow the trail a few miles and camp, while we rode in a southeasterly direction and made station 38, on a rounded peak of quartzite, 13,046 feet in elevation. From here we obtained the most striking view of the quartzite mountains. The illustration is reproduced from a topographical sketch made at this station. The point is on the brink of the great Animas Cañon, which here is over 4,000 feet in depth; a few miles farther down it is still deeper. The total length of the Grand Cañon, from the mouth of Mineral Creek down to that of Cascade, is about seventeen miles; below this, for about seven miles, it becomes very narrow and straight, with a depth of about 1,000 feet. In returning to the trail we found the country terribly cut up along the head branches of Lime Creek, and even after reaching the trail it was not the easiest we had yet had. Judging from what I have heard and seen of the pass to the west of Sultan Mountain, I think it a much better route. Some fallen timber and swamp are encountered, but not more than on this trail. We did not travel over it ourselves; but Mr. Jackson, who has been over both, gives the trail over the western pass the preference. If ever a wagon-road can be built over into

Baker's Park, from the south, it will be only by that way. The ground is very rough along the trail to a mile or so south of the crossing of Cascade Creek, when it becomes more even, and the traveling from there on is very good. Wagons could be brought this far, from the south, without the least trouble. A long line of sandstone bluffs extends parallel to the trail for several miles, and rise from 1,500 to 1,800 feet above it. The trail passes along a sort of table, with these bluffs rising above it on the west side, and the Animas Cañon bounding it on the east. Arriving at Animas City, we stabled our riding-mules in a deserted dwelling-house, and, hanging up our instruments in another, across the street from the first, made a thorough exploration of the city. We found it located on a beautiful level patch of ground, with scattering yellow pines growing all over it. It was composed of one street, with a row of log cabins on either side stretching a distance of several hundred yards. Some of the houses were nearly finished, some half done, and the sites of others were marked by two or three tiers of logs laid one above the other. All were deserted. We took possession of the best-looking one, which had a kitchen attached, and made ourselves very comfortable; eating inside and sleeping out of doors. The night was so bright and clear that we could not endure sleeping under a roof. We found several persons living in the vicinity, and from them we learned that the settlers had been time and again ordered away by the Indians, and had finally considered it best to leave. The height of this place is 6,850 feet. From Baker's Park to this point, a distance of about twenty-six miles, the Animas has a fall of 2,550 feet, or an average of 100 feet to the mile. Trout are found in the river here, but how abundantly I cannot say. They have never been caught as far up as Baker's Park—due, probably, to the falls between the two points.

Traveling down stream, the stream-bed soon widens into a very pretty valley, bearing the name of Animas Park. It extends from a point near Animas City, so called, down the river about fourteen miles, with a maximum width of two miles. The total area may be estimated at twenty square miles, but the part capable of cultivation does not amount to more than three or four thousand acres. The greater portion of this can be irrigated at little expense. In passing through it we saw corn, wheat, potatoes, turnips, and watermelons growing finely, but all abandoned on account of Indian troubles. This valley is very interesting in many respects. First it contains almost the only tillable land within a hundred miles of the mines. Its distance from Baker's Park is only thirty-five miles by the trail. It is probably the richest little valley in the Territory, and has an elevation of only 6,700 to 6,800 feet. It faces the south, and consequently is very warm, while at the same time it is near enough to the mountains to get the benefit of their great rain-fall. Near its lower end good coal is found in the greatest abundance, while a plentiful supply of good pine timber is near at hand. Farther down the river the country becomes a plain, almost perfectly barren of vegetation. After passing through the park, we made several stations, west of the river, on low hills. On station 45, which is not represented on the accompanying map, but situated just a little below the border, we found some old ruins, consisting of a couple of watch-towers; one entirely disintegrated, leaving only a hole in the ground to indicate its presence, while the other still remained about four feet high, but was completely overgrown by oak-bushes. Some white and painted pottery lay about. This point is a wooded hill, east of the Rio La Plata. The day after, we found some pottery still farther north, on station 46, which is on the map. After this we followed a road which had been used by the former settlers, over to the Florida, and made

several stations near that stream. The road soon ended, and we followed its continuation, an Indian trail, to the Pinos River. This trail, by an oversight, is not represented on the map. It leaves the Animas about half a mile north of station 46, and thence crosses over to the Florida, which it follows up for several miles, then strikes across to the Pinos, and crosses that stream at the mouth of the Vallecito; crossing thence over the next ridge, it strikes the Ute trail from Los Pinos agency. It is not much used, and is cons quently quite difficult to follow. There is some fine bottom-land on the Florida, capable of a high degree of cultivation, but of small extent. Near the junction of the Vallecito and Los Pinos is another small area of splendid land. These two streams running down from the quartzite peaks, carry at least one-half more water than any other streams of the same *drainage* area in the district.

The next day after passing this point, October 2, snow began to fall, and, camping near a peak on which we had to make a station, we quietly waited for the weather to clear off. By a remarkable accident we had halted in a splendid camping-place, there being none worthy the name for miles ahead of us, as we afterward found. Snow fell continuously for four days, and we found sitting in camp very hard work. On account of our peculiarly protected position the snow that fell near our camp melted as it fell, but a mile up stream it lay two feet deep. Had it not been for the good grass and shelter here offered, our worn-out mules would have fared badly. A thing worthy of note is the fact that very slight thunder and lightning continued through the whole of this snow-storm. Lieutenant Wheeler narrates a similar experience in this part of the country. On the fourth day the weather cleared off, and we succeeded in making our station, though on the summit the snow was two or three feet deep, which, with our shoes nearly worn out, was very disagreeable. Returning early from the peak we moved up the ridge. The trail being entirely hidden by the snow, we had to give it up, and after a very difficult day's march we succeeded in getting out of the snow only, and then had to camp in swampy ground, making our beds on pine boughs, which we cut from the trees. We knew now that winter had commenced, and we wanted to get out of the mountains as fast as our mules could carry us. The next day we crossed the divide at the head of Los Pinos River, by way of the Ute trail. The pass by this route was good, though covered with snow. In the summer it must be very easy and pleasant. We felt thankful when quite late in the afternoon we reached the Rio Grande and struck camp near the wagon-road. The next day we traveled down the road, which here is a very good one, to Antelope Park, which we found to be quite an extensive piece of plain country, forming here the valley of the Rio Grande, and continued below, by a narrow strip of low land, along the river. The elevation of the park is about 9,000 feet. There are several houses dotted about over it and farms laid out, although the elevation is too great to allow much grain to be produced. The next day, October 9, we ascended Bristol Head and made station 54. This is a very curious bald mountain, a few miles east of Antelope Park, being the southern culminating point of a high plateau. To the east it slopes down quite gently, but on the west side it falls abruptly nearly 4,000 feet to the bottom of a very curious sink. In some places the bluff is quite vertical for over a thousand feet. Being composed of trachyte, the rock breaks off along vertical planes and gives to the precipice the character peculiar to volcanic formations. The sink already mentioned is a little valley from a quarter to half a mile broad, bordered on the east by the high bluffs of Bristol Head; and, on the west, by a ridge

and bluffs reaching seven to eight hundred feet above the valley. At the lower end a narrow gate-way leads out to the Rio Grande; and, at the upper end, a beautiful lake occupies the highest part. Just above this, Clear Creek cuts through the ridge on the west side, and flows out through Antelope Park. The whole mass of this basin has, undoubtedly, fallen in; and, at one time, Antelope Park must have jutted up against the side of the mountain. We made the ascent of the peak from the sink, riding our mules the whole distance, except the first part of the climb, from the sink up to the ridge. On the summit we found the snow about a foot and a half deep. A large bear had left his tracks all over it. We found the slope to the east quite gradual and made the descent on that side instead of going down the way we came up. After camping at a point on the road to the south of Bristol Head, we moved down the Rio Grande. The only place of special interest on the way was Wagon-Wheel Gap, where the river passes for a few hundred yards between two high bluffs, about 300 feet apart. This point has evidently been, in times past, a great battle-ground between the Utes and their enemies of the plains, the Cheyennes, Arapahoes, &c. Many little heaps of rocks on the south bluff seem to have done service as rifle-pits. The toll-gate for the San Juan road is situated near this place.

We arrived at Del Norte on October 10. The town contains several hundred inhabitants, and at the present time does a considerable business with the San Juan mines. Leaving Del Norte we traveled across San Luis Valley; far behind us we could see a new but apparently greater storm than we had yet passed through gathering around the distant mountains. Crossing over Mosca Pass and down Huerfano Park we reached Pueblo October 18. The next morning we took the cars on the narrow-gauge railway, and in the evening arrived at Denver, our point of beginning.

METHODS USED IN DETERMINING THE ELEVATION OF POINTS IN THE DISTRICT.

All the elevations given in this report depend upon readings of a mercurial barometer. Where a standard barometer, whose elevation is well determined, is within a short distance, this instrument gives a very good determination of elevation. In the past summer, however, it was quite impossible to establish a base barometer in the vicinity of the region surveyed, without great expense. All the readings had to be referred to distant stations. Readings on high peaks were referred to the Signal-Service barometer on Pike's Peak, at an elevation of 14,147 feet above the sea, while readings on all points under 12,000 feet were referred to the barometer of the United States Geological Survey at Fairplay, whose elevation is 9,964.5 feet. The first of these is one hundred and fifty miles distant in a straight line from the central part of the San Juan country, while the second is one hundred and twenty-five miles distant. These distances are too great to give accurate results with the barometer. At several points in the region we succeeded in getting two readings at the same point at intervals of several days, but finding that the resulting heights, as calculated by reference to those distant bases, did not agree well enough, it was resolved to collect together all the data possible from the field-notes, and see if a fair trigonometric connection between the mountain-peaks could not be established. The result was, under the circumstances, highly satisfactory. It must be remembered,

however, that these observations were not taken with the object in view of making such a system of trigonometric levels. Moreover, the instrument used read only to minutes of arc. Supposing an error of a minute in a reading, which is not at all uncommon, the resulting error in the difference of level of two peaks from a single observation will be 15.3 feet for a distance of ten miles and 23 feet for a distance of fifteen miles. If, as is sometimes the case, the error be more than one minute, the error in the elevation will be still greater. Another large and uncertain element in the problem is refraction, which in the high mountains is so changeable as to add much to the uncertainty of the results. In many cases the observations were taken during storms, and often the peaks were sighted through breaks in the clouds, making the refraction still more uncertain.

From each station angles of elevation or depression were taken to the surrounding peaks and especially to previous stations. Had the fore sights and back sights between the several stations been simultaneous the error of the refraction correction would have been very nearly neutralized, but these two sets of observations were never taken at the same time, and in only one case on the same day. From each of two stations I always succeeded in finding some peaks which had been sighted from both. With this material on hand the distances were obtained from Mr. Wilson's plot of his secondary triangulation, which will not probably involve, in any case used, a greater error than five-hundredths of a mile, which includes the error due to shrinkage of paper, as these distances were all hastily taken off from the map with a scale. Having then the horizontal distance between the two stations and the angle of elevation or depression from one to the other, of course the difference of level can be determined. But, on account of the errors which have crept into these angles from the causes above mentioned, one determination of the difference of level is not sufficient. The back sight is then calculated, and brings a different result. For a still finer approximation, wherever vertical angles had been taken from the two stations to the same point, the height of that above and below each station was calculated. From this, another determination of the difference in the height of the two stations was determined. Then the height of another unvisited point was calculated, and so on for all the near points sighted from both stations. Each point gives one determination of the difference of the two stations. In some cases it will be found that one result is far out from the rest. This may be due to the fact that sights to different points, which have received, by mistake, the same number in the notes, have been used. Such cases are thrown out, and a mean of the rest assumed as the true difference of level. It was found that, on account of errors of refraction and imperfections of the instrument, sights over fifteen miles in length could not be depended on at all. In the following calculations no sights of that length were used, and in fact very few over ten miles have been used.

In making the calculation, the following formula was used, taken from Lee's tables:

$$dh = 0.00000485\ \mathrm{K\ A} \pm 0.000000667\ \mathrm{K}^2$$

In which dh is the difference of level of the two points, K the horizontal distance in yards, and A the number of seconds in the vertical angle used. In this formula are contained corrections for both curvature and refraction, the latter element being assumed equal to 0.078 of the curvature. On examining the notes carefully it was found that there were sights to many hundreds of different peaks, and it became a difficult problem to utilize all this material, and at the same time do it according to a sys-

tem. After a number of experiments on different methods it was found that to bring order out of this chaos, it was necessary to take up each link in the chain separately, and use all the data that could be found pertaining to it, and determine the difference of level of these two stations finally. Next, the same process had to be gone through with the line from the second point to the next station beyond, and so on. In doing this it was found that some of these lines were much better determined than the others. In finally reducing these differences of level to a common datum point, this fact might multiply the errors in the work. For instance, a number of well-determined differences of level might be transferred through a poorly-determined line, thus vitiating all with the error of the one. In order to obviate this the following scheme was adopted: A central chain of well-determined lines was carried through the heart of the mountain-mass from Mount Wilson, the most westerly of the high peaks, to station 8, five miles east of Uncompahgre Peak, in the northeast corner of the mass. From this main line several secondary branches were carried wherever the short lines could be well determined. This system covered the whole mass of mountains. Other stations, which could not be well enough determined independently, were connected with different points in the main lines. In the central line we have the following parts: From Mount Wilson to station 30, a peak east of it and distant 9.3 miles, is a fall of 383 feet, which is the mean of five determinations having a range of 32 feet; thence east to Sultan Mountain, a distance of 6.88 miles, with a fall of 536 feet, the mean of six determinations, range 23 feet; thence northeast to station 16, distant 6.60 miles, a rise of 175 feet, the mean of nine determinations, range 35 feet; thence northeast to Handie's Peak, 7.51 miles, a rise of 456 feet, the mean of eight determinations, range 54 feet; thence north to Uncompahgre Peak, distant 11.14 miles, a rise of 238 feet, the mean of nine determinations, range 49 feet; thence east to station 8, distant 4.92 miles, a fall of 1,380 feet, the mean of ten determinations, range 67 feet. This completes the central or trunk line, whose length is 46.35 miles. From Sultan Mountain a branch was extended eastward; from this peak to station 25, distant 10.28 miles, a rise of 209 feet, the mean of twelve determinations, range 67; thence to Rio Grande Pyramid, distant 8.63 miles, a rise of 197 feet, the mean of nineteen determinations, range 95.

From station 25, a branch extends to Mount Oso, distant 7.29 miles, a rise of 64 feet, the mean of seven determinations, range 37.

From station 30 a secondary branch was extended south and west.

Station 30 to Engineer Mountain, distant 6.98 miles, a fall of 926 feet, the mean of eight determinations, range 22; thence west to station 36, distant 6.76 miles, a fall of 417 feet, the mean of eleven determinations, range 51; thence to station 37, distant 3.65 miles, a rise of 94 feet, the mean of five determinations, range 35.

Another important sub-line extends from Sultan Mountain to the northwest. The first link in the chain is the line from this point to station 28. The heights of stations 30 and 16, above Sultan Mountain, having been already well determined from the central chain, I made use of all the connections between station 28 and each of these points, reducing all of them to a common point. The result from this was the following: Sultan Mountain to station 28, distant 7.86 miles, a fall of 484 feet, the mean of eighteen determinations, range 76 feet; thence to station 29, distant 3.77 miles, a rise of 324 feet, the mean of eight determinations, range 43 feet; thence to Mount Sneffels, distant 5.94 miles, a rise of 952 feet, the mean of six determinations, range 36 feet;

thence to station 34, distant 6.65 miles, a fall of 1,161 feet, the mean of five determinations, range 23 feet.

This completes all the well-determined chains. Other stations on which barometric readings had been taken, were connected with as many points in the main lines as possible, and these being reduced to a common point a mean was taken. Such points are the following: Sultan Mountain to station 10, a fall of 223 feet, the mean of eleven determinations, range 76 feet; Uncompahgre Peak to station 5, a fall of 1,498 feet, the mean of ten determinations, range 85 feet. Uncompahgre Peak to station 11, a fall of 3,624 feet, the mean of eight determinations, range 111 feet; Sultan Mountain to station 51, a fall of 835 feet, the mean of three determinations, range 75 feet; Sultan Mountain to station 48, a fall of 1,061 feet, the mean of six determinations, range 59 feet; Handie's Peak to station 13, a fall of 1,175 feet, mean of fore and back sights, range 6 feet.

Besides these there are two which depend on single determinations: First, from Sultan Mountain to the point in Baker's Park where the road crosses Cement Creek in Silverton, distant three miles, a fall of 3,961 feet. Second, from Mount Sneffels to station 32, which is obtained from sights to a common point between them, distant from Mount Sneffels 2.04 miles, and from station 32 3.75 miles, the fall is 5,050 feet. This difference of level is checked by sights to distant points to the south of station 32. These two cases are admitted, because the distances were so short as to preclude the possibility of any considerable error.

From all these results a table was made out, showing the heights of each station above or below a common datum-point. Sultan Mountain was selected as the datum point, from its central location, and also from the fact that it was situated on the great central chain of levels at its junction with the two principal sub-lines.

A second column was added, giving the height of each station as determined by the single barometric reading taken thereon. A third column was made out from the first two by adding the number in the first column to the one in the second when preceded by the minus sign, and by subtracting it when plus. This column represents the elevations above sea-level of Sultan Mountain, as determined from the barometric readings at the several stations. It will be seen that the twenty-three results have a range of 203 feet. A mean of all these was assumed as the true height of Sultan Mountain, and by reversing the previous process and adding the plus differences of height in the first column and subtracting the minus, a fourth column was obtained, giving the elevation of each station as reduced, from the mean of the twenty-three readings. A fifth column was added, giving the date of each reading on the different stations. From this it will be seen that the observations extend from August 1 to October 6, more than two months.

By examining the table carefully, it will be seen that nearly all the earlier readings give heights above the mean, and the later below it. Whether this is merely accidental or due to some physical law, I cannot tell. It will be seen that several of those stations, whose height relative to the rest has been well determined, do not appear in the table. This is due to the fact that at those stations, either from storms or other causes, we failed to get barometric readings.

Name of station.	Height above or below Sultan Mountain.	Absolute height of station from barometric reading.	Resulting height of Sultan Mountain.	Final height of station.	Date of barometric reading.
					1874.
Station 5	−629	12,770	13,399	12,737	Aug. 1
Station 8	−511	12,960	13,471	12,855	" 6
Uncompahgre Peak	+869	14,337	13,468	14,235	" 8
Station 10	−223	13,082	13,305	13,143	" 10
Station 11	−2,755	10,684	13,439	10,611	" 12
Station 13	−544	12,895	13,439	12,822	" 14
Handie's Peak	+631	14,101	13,470	13,997	" 15
Station 16	+175	13,593	13,418	13,541	" 17
Rio Grande Pyramid	+407	13,801	13,394	13,773	" 22
Sultan Mountain	0	13,298	13,298	13,366	" 31
Silverton	−3,961	9,377	13,338	9,405	" 31
Station 27	−777	12,491	13,268	12,589	Sept. 3
Station 29	−160	13,120	13,280	13,206	" 4
Station 30	+531	13,927	13,396	13,897	" 6
Station 32	−4,258	9,027	13,285	9,108	" 9
Mount Sneffels	+792	14,162	13,370	14,158	" 10
Station 34	−369	12,988	13,357	12,997	" 11
Mount Wilson	+914	14,185	13,271	14,280	" 13
Station 36	−812	12,538	13,350	12,554	" 14
Station 37	−718	12,623	13,341	12,648	" 15
Station 38	−320	13,014	13,334	13,046	" 20
Station 48	−1,061	12,321	13,382	12,305	" 30
Station 51	−835	12,518	13,353	12,531	Oct. 6
Mean	....	....	13,366		

With the elevations of these stations determined, the heights of unvisited points were obtained by applying the difference of level, as obtained from the vertical angle, to the height of the station from which the angle was taken. As most of the unvisited points are sighted from many stations, we have for each a number of determinations of which the mean is taken. Many of these points are quite as well determined as some of the stations.

As it was impossible to connect all the peaks with the scheme of trigonometric levels, it was thought best to give the heights of such as nearly as it could be obtained from the data at hand.

All these, it must be understood, depend on a single reading of the mercurial barometer, not of the small aneroid. The latter instrument was found to be worse than useless. Only one height depends on an aneroid reading, that is Bear Creek Pass, but as here we had two different sets of readings of three different aneroids, compared each morning with the mercurial barometer, I thought best to put the height in the list, but it must not be considered as very accurate.

In the following table are given, as nearly as may be, the heights of all the peaks in the San Juan country above 13,000 feet, besides stations and other points of interest. Some of the latitudes and longitudes have been calculated, while the others have been taken from Mr. Wilson's plot of his secondary triangulation, at a scale of two miles to one inch. Some of these peaks being points of the primary triangulation, their latitude and longitude will be more accurately determined when that work is finished.

The first column in the table indicates the topographical designation of each peak. The double numbers indicate unvisited stations. For instance, 14—9 signifies the fourteenth peak sighted from station 9, which ever afterward bears that designation unless occupied as a station. The term "Baker's Park rectangle" signifies the projection rectangle included between latitude 37° 45′ and 38° and longitude 107° 30′ and 107° 45′, in which Baker's Park is situated. On the map the name, by a sad oversight, was omitted, but its position may be known from the fact that Howardville and Silverton are situated within it.

The absolute heights of the list may be out considerably, but the relative heights are probably very near the truth. Whenever any point in the system is well connected with sea-level either by a long series of barometric readings or by a line of levels, it will only be necessary to apply the trigonometric differences of height to obtain a very complete and accurate table of elevations. It is proposed to make next summer a connection with a standard barometer at Howardville.

Baker's Park rectangle.

Name or number of peak.	Height above the sea.	Latitude.			Longitude.		
		°	′	″	°	′	″
Station 17	12,897	37	45	32	107	33	30
2—17	13,390	37	46	00	107	36	8
Sultan Mountain	13,366	37	47	15	107	42	2
Mount Kendall	13,380	37	47	22	107	36	51
10—16	13,300	37	47	41	107	37	30
11—16	13,030	37	47	45	107	38	20
8—16	13,400	37	47	57	107	35	47
6—14	13,450	37	48	2	107	32	32
Galena Mountain	13,290	37	50	2	107	34	8
Station 16	13,541	37	51	30	107	37	10
13—14	13,480	37	51	37	107	39	8
2—15	13,360	37	51	54	107	35	48
Station 27	12,589	37	52	21	107	41	58
12—9	13,770	37	53	27	107	31	49
11—9	13,830	37	53	27	107	31	18
Station 28	12,882	37	54	7	107	41	10
17—14	13,390	37	54	33	107	36	24
11—27	13,630	37	54	39	107	44	52
Handie's Peak	13,997	37	54	50	107	30	4
2—10	13,440	37	54	55	107	37	6
Station 15	13,675	37	56	42	107	33	20
1—10	13,720	37	56	57	107	32	3
3—10	13,770	37	57	2	107	32	48
Station 29	13,206	37	57	24	107	41	58
3—8	13,480	37	57	50	107	29	35
5—26	13,120	37	58	12	107	41	11
8—5	13,290	37	58	27	107	35	11
5—10	13,787	37	59	30	107	44	48
Station 10	13,143	37	59	40	107	35	39
1—5	13,250	37	59	47	107	30	20
12—10	13,420	38	00	12	107	44	23
57—9	13,120	38	1	16	107	37	5
13—10	13,490	38	1	17	107	44	6
14—10	13,080	38	1	46	107	43	49
21—1	13,970	38	3	42	107	30	30
10—10	13,010	38	4	52	107	31	52

East of Baker's Park.

Name or number of peak.	Height above the sea.	Latitude.			Longitude.		
		°	'	"	°	'	"
Station 20	12,050	37	46	58	107	19	36
Mount Cauby	13,274	37	47	7	107	30	51
Station 18	13,656	37	47	52	107	25	42
10—18	13,614	37	48	54	107	26	36
8—1	13,530	37	51	34	107	23	57
12—1	13,815	37	51	58	107	27	54
10—13	13,747	37	54	40	107	28	42
Station 13	12,822	37	55	27	107	28	15
Station 12	13,967	37	55	30	107	25	21
15—1	14,004	37	56	36	107	25	6
4—3	13,780	37	56	56	107	23	42
16—1	13,540	37	57	17	107	25	00
3—3	13,700	37	57	24	107	22	30
6—13	13,600	37	57	52	107	25	10
2—3	13,620	37	57	55	107	21	21
18—1	13,520	37	58	28	107	26	18
17—1	13,660	37	58	53	107	25	24
Station 11	10,611	38	1	34	107	17	36
Station 5	12,737	38	2	00	107	14	24
Station 8	12,855	38	3	16	107	22	18
14—5	13,510	38	3	57	107	29	38
Uncompahgre Peak	14,235	38	4	21	107	27	32
24—1	13,670	38	6	27	107	26	44
31—1	13,080	38	7	21	107	27	18

West of Baker's Park.

		°	'	"	°	'	"
9—31	13,120	37	44	54	107	51	51
1—9	13,740	37	45	27	107	51	31
32—9	13,697	37	46	00	107	49	23
21—30	13,377	37	46	6	107	47	18
20—30	13,420	37	46	15	107	46	58
22—30	13,730	37	46	47	107	52	7
23—30	13,180	37	47	42	107	52	54
Station 30	13,897	37	48	2	107	49	31
6—27	13,760	37	49	28	107	48	18
4—27	13,170	37	49	33	107	46	6
5—27	13,400	37	49	34	107	47	3
Lizard's Head	13,160	37	50	13	107	56	51
Lizard's Head, base of column	12,868		ditto.			ditto.	
7—27	13,400	37	50	16	107	47	12
Mount Wilson	14,280	37	50	23	107	59	18
1—35	14,195	37	50	25	108	00	7
4—9	14,050	37	51	40	107	58	54
8—27	13,650	37	51	50	107	46	31
3—30	13,690	37	52	27	107	48	22
2—30	13,480	37	52	46	107	49	41
9—27	13,470	37	53	27	107	45	7
10—27	13,550	37	53	57	107	45	00
Station 32	9,108	37	57	12	107	52	20
1—29	13,590	37	58	38	107	47	12
14—30	13,810	37	59	20	107	49	15
2—29	13,750	37	59	26	107	47	53
12—30	13,730	37	59	38	107	50	48
Mount Sneffels	14,158	38	0	17	107	47	21
11—30	13,500	38	0	36	107	51	33
Station 34	12,997	38	1	54	107	54	23

Quartzite Peaks, south of Baker's Park.

Name or number of peak.	Height above the sea.	Latitude.			Longitude.		
		°	′	″	°	′	″
Station 48	12,305	37	29	20	107	35	56
9—23	13,650	37	34	55	107	28	42
21—31	13,000	37	34	57	107	40	18
10—23	13,275	37	35	12	107	29	6
11—23	13,110	37	35	48	107	30	18
8—23	13,380	37	35	52	107	29	2
Mount Oso	13,640	37	36	29	107	29	25
9—21	13,630	37	36	31	107	34	24
13—23	13,180	37	36	41	107	27	25
1—23	13,800	37	36	48	107	34	44
2—23	13,580	37	37	9	107	32	59
7—9	14,054	37	37	21	107	35	21
Mount Æolus	14,054	37	37	24	107	37	12
8—9	14,033	37	37	43	107	35	32
1—39	13,728	37	37	43	107	38	16
Pidgeon's Peak	13,928	37	38	2	107	38	36
10—21	13,746	37	38	40	107	37	27
11—21	13,783	37	38	49	107	34	51
1—14	13,560	37	39	52	107	32	14
5—23	13,680	37	39	52	107	35	18
1—38	13,100	37	39	54	107	43	22
5—14	13,600	37	40	18	107	34	36
2—14	13,580	37	40	19	107	32	42
4—14	13,650	37	40	27	107	34	00
3—14	13,700	37	40	43	107	33	24
12—14	13,800	37	40	52	107	35	18
9—14	13,750	37	40	57	107	34	47
16—14	13,730	37	41	12	107	35	22
7—14	13,831	37	41	27	107	35	56
8—14	13,800	37	41	42	107	36	25
4—17	13,540	37	41	56	107	33	18
Station 38	13,046	37	41	59	107	41	20

Southeast of Baker's Park.

		°	′	″	°	′	″
Station 51	12,536	37	29	52	107	22	24
Station 22	13,020	37	36	6	107	23	48
11—17	13,090	37	39	38	107	29	11
10—17	13,200	37	40	38	107	29	40
12—17	13,170	37	40	39	107	30	15
Rio Grande Pyramid	13,773	37	40	50	107	23	21
3—18	13,220	37	41	24	107	22	17
9—17	13,090	37	41	20	107	29	57
Station 24	12,957	37	41	46	107	29	55
2—18	13,210	37	41	55	107	21	56
7—17	13,310	37	42	14	107	28	38
8—17	13,260	37	42	16	107	29	29
14—14	13,430	37	42	47	107	27	18

Miscellaneous elevations.

Name or number of peak.	Height above the sea.	Latitude.			Longitude.		
		°	′	″	°	′	″
Station 2*	13,560	37	58	12	107	4	3
Station 3*	12,670	38	7	42	107	12	35
Station 7*	9,100	38	16	48	107	9	6
Engineer Mountain	12,971	37	42	4	107	48	12
Station 36	12,554	37	42	48	107	55	37
Station 37	12,648	37	41	19	107	14	11
Station 39	10,613	37	35	12	107	49	55
Station 42*	10,580	37	25	40	107	55	42
Station 44*	8,100	37	16	45	107	49	20
Station 45*	8,300	37	11	18	107	59	24
Station 47*	8,930	37	19	35	107	42	15
Bristol Head*	12,800	37	47	45	107	3	6
Howardville	9,700	37	50	12	107	35	42
Silverton	9,400	37	48	48	107	39	40
Lake Fork Pass*	12,540						
Cunningham Pass*	12,090						
Pass east of Sultan Mount*	10,460						
Pass west of Sultan Mount*	11,570						
Pass at head of Mineral Creek*	11,098						
Bear Creek Pass (*a*)	12,600						
Weminuche Pass*	10,f00						

The star denotes points whose heights depend on a single reading of mercurial barometer.
(*a*) Height determined by aneroid barometer.

NOTES USEFUL FOR THE LOCATION OF MINERS' MONUMENTS IN BAKER'S PARK.

Sultan Mountain is the peak at the south end of Baker's Park. In the following notes the monument built by this party on the southern knob is used as the station. Station 16 is a high massive peak, two miles northwest of Howardville, but not quite visible from the town; it may be seen from a point a little up the side of Galena Mountain. On the summit we left a small monument of stones. The latitude of station 16 is 37° 51′ 30″.5, and its longitude 107° 37′ 9″.8. The latitude of Sultan Mountain is 37° 47′ 15″, and its longitude 107° 42′ 1″.5; at station 16, Sultan Mountain bears south 42° 11′ west; at Sultan Mountain, station 16 bears north 42° 8′ east. The distance between the two points is 6.60 miles. By using this as a base any engineer can locate accurately a monument at any point visible from the two stations. Silverton and the whole lower end of the park are visible from both points, as well as points on the side of Galena Mountain, and also others near Arastra Gulch.

Declination of magnetic needle.

Locality.	Declination.	Date.
		1874.
Station 11	E. 15° 15′	August 12
Rio Grande Pyramid	E. 12° 56′	August 22
Station 30	E. 8° 59′	September 6
Engineer Mountain	E. 13° 56′	September 7
Station 32	E. 15° 59′	September 9
Station 34	E. 16° 55′	September 11
Mount Wilson	E. 13° 8′	September 13
Station 36	E. 16° 15′	September 14
Station 37	E. 14° 23′	September 15

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